Age-related Smell Changes and Their Effects on the Health Status of Older Americans

Emily Duran Frontera
University of Maine, emily.duranfrontera@maine.edu

Follow this and additional works at: https://digitalcommons.library.umaine.edu/etd
Part of the Dietetics and Clinical Nutrition Commons

Recommended Citation
Duran Frontera, Emily, "Age-related Smell Changes and Their Effects on the Health Status of Older Americans" (2019). Electronic Theses and Dissertations. 3048.
https://digitalcommons.library.umaine.edu/etd/3048

This Open-Access Thesis is brought to you for free and open access by DigitalCommons@UMaine. It has been accepted for inclusion in Electronic Theses and Dissertations by an authorized administrator of DigitalCommons@UMaine. For more information, please contact um.library.technical.services@maine.edu.
AGE-RELATED SMELL CHANGES AND THEIR EFFECTS ON

THE HEALTH STATUS OF OLDER AMERICANS

By

Emily Durán-Frontera

B.S. University of Maine, 2017

A THESIS

Submitted in Partial Fulfillment of the

Requirements for the Degree of

Master of Science

(in Food Science and Human Nutrition)

The Graduate School

The University of Maine

August 2019

Advisory Committee:

Mary Ellen Camire, Professor of Food Science and Human Nutrition, Advisor

Mona Therrien, Dietetic Internship Program Director, and Lecturer

Valerie Duffy, Professor and Graduate Program Director in Allied Health
Olfactory impairment is a prevalent but underreported condition among older adults in the United States (U.S.). In the elderly, this impairment is associated with a host of adverse health conditions and issues that affect the quality of life. This study investigated the prevalence of smell disorders in older adults over 60 years of age, the potential risk factors for smell deterioration, and the influence of smell dysfunction on health status using the data collected through the National Health and Nutrition Examination Survey (NHANES) 2013-2014 questionnaires and examination components. Participants were categorized as smell impaired (‘SI Present’) if they were unable to identify five or more of the scents correctly. Similarly, participants were classified as having a smell alteration (‘SA Present’) if they reported: a problem in smell in the past 12 months, worse sense of smell since age 25 and or a phantom smell. A total of 1287 people were suitable for inclusion. The NHANES participants included for these analyses were mainly non-Hispanic white (52.7%), college-educated (54.5%), and lived with someone (60%). Among subjects, 279 persons were smell-impaired, and 44.8% of those
individuals were aged 75-80. The prevalence for the general U.S population of smell impairment was 15.4% and 17.5% for smell alteration. Meanwhile, the incidence of smell dysfunction (smell impairment and or smell alteration) in the U.S. population was 29.8%.

After adjusting for confounding variables in logistic regression, smell impairment was significantly associated with age 75-80 years (OR: 3.51, CI: 2.07-5.95), and an educational level of high school or less (OR: 1.70, CI: 1.40-2.30), poor health self-ratings (OR: 2.63, CI: 1.30-5.40), more sedentary hours each day (OR: 1.07, CI: 1.03-1.11), and presence of smell alteration (OR: 3.00, CI: 2.10-4.60). Furthermore, persons with normal muscle and hand grip strength were less likely to have a smell impairment or alteration. However, the role of appetite could not be determined because responses of “poor appetite” were coded as yes and tallied with “overeating” responses. Factors significantly associated with lower risks for smell impairment were being female, younger (in the 60-64 age range), not IADL (Instrumental Activities of Daily Living) impaired, and physically active. Moreover, smoking, appetite, weight changes, and other self-reported smell variables were not significantly associated with the presence of a smell disorder.

Overall, based on our findings, the prevalence of smell dysfunction increases with age. However, this change does not happen until the age of 75. This dysfunction also has adverse effects on the health status of older adults in the U.S. . Healthcare practitioners may be able to improve the quality of life of patients by screening for smell alterations and developing early interventions.
Further prospective studies are warranted to investigate the causal links between olfactory impairment, medication, smoking, cognitive function, and food intake. Further research is also needed to determine whether preservation of olfaction can forestall age-related reductions in appetite, and subsequent loss in body mass, particularly muscle. The inclusion of persons older than 80 years in the NHANES sampling would provide useful data for researchers since the number of persons older than eighty is growing in this nation and elsewhere.
DEDICATION

To my mother, my strength.
ACKNOWLEDGMENTS

I wish to acknowledge all of the people who gave me their time and input into this seemingly never-ending project. First of all, my gratitude goes to my mother, whose support and humor helped through some of the most challenging periods of my graduate training.

I also want to thank my advisor, Dr. Mary Ellen Camire for all her guidance, comments, and feedback on this research. I am indebted to her for the challenges she laid out and for always ensuring I didn’t wander too far off track. I would also like to gratefully acknowledge the flexibility and invaluable feedback given to me by my committee – Mary Ellen Camire, Mona Therrien, and Valerie Duffy. Lastly, I would like to thank the University of Maine Graduate School for providing me with the Thurgood Marshall Tuition Scholarship for the past two years.

My special thanks and love go to my fiancé, Ian. He has not only provided support and encouragement throughout my graduate training, but he has also been extremely patient. He has added both humor and optimism to my life.
TABLE OF CONTENTS

DEDICATION .............................................................................................................. ii

ACKNOWLEDGMENTS ............................................................................................. iii

LIST OF TABLES ....................................................................................................... xi

LIST OF FIGURES .................................................................................................... xvii

CHAPTER

1. INTRODUCTION .................................................................................................. 1

2. BACKGROUND INFORMATION ........................................................................... 3
   Demographics of the Aging Population ................................................................. 3
   Community Dwelling (non-institutionalized) vs. Institutionalized Older Adults ...... 4
   Changes During Aging .......................................................................................... 5
      Weight Loss ........................................................................................................ 5
      Inflammation ...................................................................................................... 6
      Gastrointestinal Tract ......................................................................................... 7
      Appetite ............................................................................................................... 8
      Sensory Function Decline .................................................................................. 10
      Depression ......................................................................................................... 11
      Medications ....................................................................................................... 12
      Oral Health Status ............................................................................................. 12
   Introduction to Olfactory Function ....................................................................... 13
   Olfactory Function ............................................................................................... 15
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Olfactory Function and Age</td>
<td>16</td>
</tr>
<tr>
<td>Smell Changes Consequences in Older Adults</td>
<td>17</td>
</tr>
<tr>
<td>Nutritional Effects</td>
<td>17</td>
</tr>
<tr>
<td>Loss of Enjoyment</td>
<td>18</td>
</tr>
<tr>
<td>Selection of Foods</td>
<td>18</td>
</tr>
<tr>
<td>Malnutrition</td>
<td>20</td>
</tr>
<tr>
<td>Handgrip Strength</td>
<td>20</td>
</tr>
<tr>
<td>National Health and Nutrition Examination Survey (NHANES)</td>
<td>21</td>
</tr>
<tr>
<td>What is NHANES?</td>
<td>21</td>
</tr>
<tr>
<td>History of NHANES</td>
<td>24</td>
</tr>
<tr>
<td>Overview of the NHANES Sample Design</td>
<td>25</td>
</tr>
<tr>
<td>Mobile Examination Center (MEC)</td>
<td>26</td>
</tr>
<tr>
<td>Household Interview</td>
<td>26</td>
</tr>
<tr>
<td>Screener</td>
<td>26</td>
</tr>
<tr>
<td>HYPOTHESES</td>
<td>27</td>
</tr>
<tr>
<td>OBJECTIVES</td>
<td>27</td>
</tr>
<tr>
<td>3. MATERIALS AND METHODS</td>
<td>28</td>
</tr>
<tr>
<td>Study Population</td>
<td>28</td>
</tr>
<tr>
<td>Participants</td>
<td>28</td>
</tr>
<tr>
<td>Examination Components</td>
<td>28</td>
</tr>
<tr>
<td>Exclusion and Inclusion Criteria</td>
<td>29</td>
</tr>
<tr>
<td>Smell Disorder Assessment</td>
<td>31</td>
</tr>
</tbody>
</table>
Weight .................................................................................................................. 51
  Current Weight ................................................................................................. 51
  Body Mass Index (BMI) ..................................................................................... 52
  Weight Changes ................................................................................................. 54
    One-year Weight Change .................................................................................. 54
    Ten-year Weight Change .................................................................................. 55
Handgrip Strength ................................................................................................. 56
  Average Handgrip Strength ............................................................................... 56
  Muscle Grip Strength Classification ................................................................... 57
Physical Activity and Functioning ......................................................................... 59
  Physically Active ............................................................................................... 59
  Sedentary (Inactive) Hours ................................................................................ 59
Instrumental Activities of Daily Living (IADL) Impairment ......................... 61
Self-Rated Health Assessment ............................................................................. 62
Poor Appetite or Overeating ................................................................................ 63
Smell Disorder Assessment Variables ............................................................... 64
Smell Examination Component .......................................................................... 64
  Individual Smell Test ........................................................................................ 64
  Scent Test Total Scores ...................................................................................... 64
Presence of Smell Impairment ............................................................................. 66
Smell Questionnaire Component ....................................................................... 67
Smell Questionnaire Variable ............................................. 67
Smell Alteration Total Score ............................................. 68
Self-Reported Smell Alteration ........................................... 68
Smell Dysfunction .............................................................. 72
Prevalence Rates ................................................................ 73
Hypothesis Testing .............................................................. 75
   Smell Disorder Assessment Variables .............................. 75
   Smell Impairment .......................................................... 75
   Smell Alteration ............................................................ 76
Scent and Smell Score Variables ........................................ 80
Health Assessment Variables ............................................. 82
Regression Analyses ............................................................. 84
   Logistic Regression ......................................................... 84
   Smell Disorder Variables ................................................ 84
   Selected Scents from Smell Test ...................................... 84
   Gas Scent .................................................................... 84
   Smoke Scent ................................................................. 85
   Grape Scent ................................................................. 85
   Smell Impairment .......................................................... 88
   Smell Alteration ............................................................ 91
Linear Regression ............................................................... 92
Appendix A. Original Coding for Variables .............................................. 142
Appendix B. Missing Values ................................................................. 149
Appendix C. Distributions .................................................................... 153
Appendix D. Unadjusted and Adjusted Means ....................................... 155
Appendix E. Hypothesis Testing Interactions ........................................ 157
BIOGRAPHY OF THE AUTHOR ............................................................. 159
**LIST OF TABLES**

| Table 3.1. | Distribution of participants who reported hand surgery ................................31 |
| Table 3.2. | Smell examination variables, coding and labeling ...........................................36 |
| Table 3.3. | Study sample socio-demographic variables, coding and label ............................37 |
| Table 3.4. | Weight history variables, coding and label of the study sample (WHQ) ......................39 |
| Table 3.5. | Muscle Strength/Grip test (MGX) examination variables’ label, meaning, and name for the study sample .................................................................42 |
| Table 3.6. | Distribution of participant’s dominant hand ...................................................43 |
| Table 3.7. | Physical activity and functioning variables’ label, meaning, and name for the study sample .................................................................45 |
| Table 3.8. | Self-rated health variable coding and labeling .................................................46 |
| Table 3.9. | Presence of poor appetite or overeating (appetite) variable, coding, and labeling .................................................................46 |
| Table 5.1. | Summary of socio-demographic characteristics of NHANES participants included in this study .................................................................51 |
| Table 5.2. | Current weight (kg) mean and quartiles ............................................................52 |
| Table 5.3. | Current weight means (kg) and standard errors (SE) by age and gender ................52 |
| Table 5.4. | Current weight means and standard errors (SE) by age ........................................52 |
| Table 5.5. | Distribution of Body Mass Index (BMI, kg/m²) ....................................................53 |
| Table 5.6. | Categories of BMI distribution by gender and age .............................................53 |
Table 5.7. One-year self-reported weight change distribution by gender and age .................................................................54
Table 5.8. Ten-year self-reported weight change distribution by gender and age ........................................................................55
Table 5.9. Average handgrip strength (kg) mean and quartiles ..................................................56
Table 5.10. Average handgrip strength (kg) frequency and means by gender ..........................56
Table 5.11. Average handgrip strength (kg) frequency and means by age .............................56
Table 5.12. Average handgrip strength (kg) frequency and means by race .........................57
Table 5.13. Muscle grip strength classification distribution by gender .................................58
Table 5.14. Muscle grip strength classification distribution by gender and age ...............58
Table 5.15. Distribution of the categories of BMI by muscle grip strength .........................59
Table 5.16. Physical activity distribution by gender and age .................................................60
Table 5.17. Sedentary hours means by age and gender .........................................................60
Table 5.18. Means and quartiles for hours of sedentary activity .........................................61
Table 5.19. Instrumental Activities of Daily Living (IADL) impairment distribution by gender and age ..................................................................................................................61
Table 5.20. Self-rated health condition distribution .................................................................62
Table 5.21. Self-rated health assessment distribution by gender and age ..........................62
Table 5.22. Self-reported poor appetite or overeating .............................................................63
Table 5.23. Distribution of poor appetite or overeating by gender and age .......................63
Table 5.24. Distribution of the individual scents from the smell test ..................................64
Table 5.25. Gender and age distribution of persons who failed to identify the grape scent correctly ................................................................. 65
Table 5.26. Gender and age distribution of persons who failed to identify the smoke and gas scent correctly ................................................................. 65
Table 5.27. Distribution of the total scent test scores ................................................................. 66
Table 5.28. Distribution of the smell impairment ................................................................. 66
Table 5.29. Distribution of smell impairment by age ................................................................. 67
Table 5.30. Distribution of smell impairment by gender ................................................................. 67
Table 5.31. Presence of smell impairment (‘SI Present’) distribution by gender and age ........................................................................................................... 67
Table 5.32. Distributions of the smell alteration questionnaire variables responses ........................................................................................................... 69
Table 5.33. Affirmative responses for smell alteration questionnaire variables by gender and age ........................................................................................................... 69
Table 5.34. Distributions smell confounding questionnaire variables responses .......... 70
Table 5.35. Distribution of smell alteration total scores ................................................................. 70
Table 5.36. Distribution of self-reported smell alteration ................................................................. 70
Table 5.37. Distribution of self-reported smell alteration by age ................................................. 71
Table 5.38. Distribution of self-reported smell alteration by gender ................................................. 71
Table 5.39. Distribution of the presence of a self-reported smell alteration (‘SA Present’) by gender and age ........................................................................................................... 71
Table 5.40. Distribution of the presence of a smell dysfunction ............................................72
Table 5.41. Distribution of smell dysfunction by gender .........................................................72
Table 5.42. Distribution of the presence of a smell dysfunction by age .........................72
Table 5.43. Percent and population estimates of adults over 60 years of age
with smell disorders in the U.S ............................................................................................74
Table 5.44. Percentage estimates of adults over 60 years of age with smell
disorders in the U.S by gender .............................................................................................74
Table 5.45. Prevalence of the presence smell impairment and smell alteration
by sociodemographic characteristics in participants 60+ years
(N=1285) ............................................................................................................................77
Table 5.46. Prevalence of the presence smell impairment and smell alteration
by health characteristics in participants 60+ years (N=1285) .........................78
Table 5.47. Prevalence of the presence smell impairment and smell alteration
by other smell variables in participants 60+ years (N=1285) .........................79
Table 5.48. Continuous variables means and p-values by smell impairment in
participants 60+ years (N=1285) ......................................................................................80
Table 5.49. Continuous variables means and p-values by smell alteration in
participants 60+ years (N=1285) ......................................................................................80
Table 5.50. Individual scents from the scent test and their statistically significant
interactions (p<0.05) .............................................................................................................81
Table 5.51. Smell scores variables and their significant interactions (p<0.05) ..........82
Table 5.52. Health characteristic variables and their significant interactions (p-values<0.05) ..................................................................................................................83

Table 5.53. ORs and 95% CIs for the risk factors associated with failing to identify the scent gas from the smell test .................................................................86

Table 5.54. Contrast estimate probability for gas scent and average handgrip strength (and age and gender) ...............................................................................86

Table 5.55. ORs and 95% CIs for the risk factors associated with failing to identify the scent smoke from the smell test .................................................................87

Table 5.56. ORs and 95% CIs for the risk factors associated with failing to identify the scent grape from the smell test .................................................................88

Table 5.57. ORs and 95% CIs for the risk factors associated with the presence of a smell impairment (‘SI Present’) .................................................................90

Table 5.58. OR and 95% CI for risk factors associated with the presence of a smell alteration .................................................................................................91

Table 5.59. Smell Test Total Score crude (undaj.) and adjusted estimates and p-values ..................................................................................................................93

Table 5.60. Smell Alteration Total Score crude and adjusted estimates and p-values ..................................................................................................................94

Table 5.61. Average Handgrip strength crude and adjusted estimates and p-values ..................................................................................................................96

Table 5.62. Sedentary Hours crude and adjusted (adj.) estimates (est.) and p-values ..................................................................................................................97
Table 6.1  Comparison between 2010 U.S Census estimated (%) and this study .....98

Table 7.1  Possible variables to be included in future studies from the mental health-depression screener questionnaire (DPQ-H) .................119

Table A.1.  Original variable names, coding and meaning from the 2013-2014 NHANES data for older adults 60 years and older .................................142

Table B.1.  Frequency and percentages of missing values of the NHANES 2013-2014 variables of interest .................................................................149

Table D.1.  Unadjusted and adjusted means for continuous variables ...............155

Table D.2.  Gender and age unadjusted and adjusted means for current weight ........................................................................................................155

Table D.3.  Gender and age unadjusted and adjusted means for average handgrip strength .......................................................................................156

Table D.4.  Gender and age unadjusted and adjusted means for sedentary hours .....................................................................................................156

Table E.1  Hypothesis testing results for not significant(p>0.05) association on individual scents variables .................................................................157

Table E.2.  Hypothesis Testing results for not significant (p>0.05) associations on smell scores variables .................................................................157

Table E.3.  Hypothesis testing results for not significant (p>0.05) associations on health assessment variables ...............................................................158
**LIST OF FIGURES**

| Figure 2.1 | Factors linked to decreased appetite among older adults ..................................10 |
| Figure 2.2 | Factors that can affect smell function among adults ........................................14 |
| Figure 3.1 | Inclusion criteria for the study sample and the number of participants ..................................................30 |
| Figure 3.2 | Criteria used for classifying individuals as physically active .................. 44 |
| Figure 5.1 | Percent estimates of smell disorders for the U.S population by race .................................................................74 |
| Figure C.1 | Shows the Distribution (%) of the current weight in kg .................................153 |
| Figure C.2 | Shows the Distribution (%) of the average dominant hand grip strength in kg ..................................................................................153 |
| Figure C.3 | Shows the Distribution (%) of the hours of sedentary activity ...............154 |
CHAPTER 1

INTRODUCTION

In older adults, the prevalence of olfactory impairment increases with age (Correia et al., 2016). Researchers have estimated that olfactory dysfunctions affect 13.5% of the U.S. population aged 40 and over (Liu et al., 2016). Similarly, others have proposed that 50% of the older adults 65 to 80 years of age and 75% of those older than 80 years of age suffer from a decreased olfactory function (Boyce & Shone, 2006).

According to Doty and Kamath (2014), the high estimates of smell alterations in the elderly is suspected to be due to several factors, such as changes in olfactory epithelial cells leading to altered nasal mucous production, dysfunctional nasal engorgement, and a reduction in the regeneration of olfactory receptors.

Loss of smell has the potential to partially explain why older adults face challenges with obtaining adequate nutrition and have a lower quality of life (Rasmussen et al., 2018); “olfactory function influences the food and nutrient intake into the body and warns of environmental hazards making it a critical component of health in older adults” (Duda-Sobczak et al., 2017). Previous studies have also established an extensive range of lifestyle and socioeconomic factors such as diabetes, age, gender, hypertension, body mass index (BMI), blood triglycerides, and neuropathy as correlating factors to smell impairment (Rasmussen et al., 2018). Perhaps the most important relationship established has been between olfactory function and cognitive health; poor olfaction is regarded as a potential risk factor for neurodegenerative diseases like Parkinson’s and Alzheimer’s disease (Doty, 2011; Field, 2015; DeMaagd &
Philip, 2015), and schizophrenia (Field, 2015). Therefore, poor olfaction can lead to a host of problems that adversely affect older populations, including quality of life decline, safety concerns, and dietary changes (Rasmussen et al., 2018, Gouveri et al., 2014). However, the association between impairment of smell in patients 60 years and older and health status has, to our knowledge, never been investigated. For this reason, this study aims to examine the prevalence of olfactory dysfunctions in older adults and the risk factors for smell deterioration and the association between smell impairment and health status. Most medical providers do not routinely check for the presence of smell disorders due to lack of awareness (NHANES Taste and Smell Examination Manual, 2013), thus understanding the role that smell decline has on health may improve health interventions.

The American National Health and Nutrition Examination Survey (NHANES) has a nationally representative nutritional data collection (CDC, 2018). NHANES data provides a tool to address emerging public health issues and objective data on health conditions for the non-institutionalized U.S. population. Their publicly available data made it possible to study smell function on adults over 60 years of age without having to collect the data separately. Thus, the NHANES data proved to be a valuable resource in our research aims.
CHAPTER 2

BACKGROUND INFORMATION

Demographics of the Aging Population

The world’s population is aging so rapidly that the proportion of those over 60 years of age will double from 11% to 22% between 2000 and 2050 (Giezenaar et al., 2016, Ogawa et al., 2016). Similarly, according to Ortman and Velkoff (2014), in 2050, the population aged 65 and over is projected to be 83.7 million, almost double its estimated population of 43.1 million in 2012. The estimated life expectancy at birth in the United States increased from 47 years in 1900 to 79 years in 2010 (Atalayer & Astbury, 2013), and the population is now expected to live longer than ever before.

The researchers for Maine’s State Plan on Aging stated that in 2015 Maine had a population of 1.3 million residents, of whom 19% were aged 65 and older; this segment is growing faster than either the New England or the national average (Office of Aging and Disability Services, 2016). Moreover, by 2030, Maine’s population aged over 65 will reach 28% of the total population, while the state’s median age will increase from 43 in 2010 to 46 in 2030 (Office of Aging and Disability Services, 2016; Lee, 2017). Maine’s State Plan on Aging also explained that those changes will be critical factors for interventions in Maine, not only because it has one of the oldest populations in the country, but because of the “additional challenges in the transportation and provision of needed services caused by the state’s rural nature” (Office of Aging and Disability Services, 2016).
Community Dwelling (Non-institutionalized) vs. Institutionalized Older Adults

The literature classifies seniors into two categories: community-dwelling and institutionalized (Ortman & Velkoff, 2014). Community-dwelling elderly refers to older individuals who live in the community on their own as opposed to those taken care of by a third entity (Ortman & Velkoff, 2014). On the other hand, institutionalized older adults are those who were placed or committed to the care of a specialized institution (such as a psychiatric hospital or nursing home).

Whether or not a senior remains community-dwelling or institutionalized is often a good indicator of their health and functional status. Studies have established that hospitalized, and institutionalized older adults are on average, sicker, more disabled, and, consequently, under more intensive supervision by professional caregivers (Roberts et al., 2007; Tuunainen et al., 2014). According to Roberts and Payette (2007), assessing the nutritional status of institutionalized seniors thereby poses less of a challenge than evaluating the condition of community-dwelling seniors. This conclusion is due to the fact non-institutionalized older adults are typically responsible for their grocery shopping, picking up medication, meal planning, preparation, and consumption – tasks that are all determinants of dietary intake that can become more taxing with age (Roberts et al., 2007; Chihuri et al., 2016). Additionally, community-dwelling older individuals (and their caregivers) may not report nutrition-related ailments, or changes in nutritional patterns because these issues are accepted as part of the natural course of aging.
**Changes During Aging**

During the aging process, many changes occur that have a significant impact on the general health and well-being of an individual (Atalayer & Astbury, 2013). The aging process changes are classified into three major aspects: biological, psychological, and social (Santana & Sena, 2012; Soares, 2014). The biological aspect constitutes the changes to the body of the individual, such as wrinkles, hair whitening, reduced height, sensory changes, among others (Santana & Sena, 2012; Soares, 2014). The psychological aspect comprises such considerations as the fear of death, the fear of loneliness, and dealing with the natural and social losses that come with age (Santana & Sena, 2012; Soares, 2014). The social aspect includes concerns such as rejection in the work field and relationships with others (Santana & Sena, 2012; Soares, 2014).

**Weight Loss**

A study by Rolls et al. (1994) mentioned that after the age of 65-70, decreases in body weight are common in the elderly, even in those demonstrating a previously healthy body weight, and that said reductions could be as high as 27% in high-risk populations. A more recent study confirmed these findings by establishing that, generally, there is a weight decrease in old age, which could lead to adverse clinical outcomes. This weight change is associated with alterations in body composition, such as an increased proportion of body fat and decreased lean muscle mass and body water (St-Onge & Gallagher, 2010).

One of the leading causes of the involuntary loss of weight and lean muscle mass is the reduced dietary intake among the older population (Roberts et al., 2007).
Giezenaar et al. (2016) reported evidence of this within the NHANES III cross-sectional study that reported a decrease in the caloric intake, between the ages of 20–29 and 70–79 years of 38% (1138 kcal/day) in older men and 27% (522 kcal/day) in older women. Giezenaar et al. (2016) also showed that energy intake was 16% lower in older as compared to younger men.

**Inflammation**

Increased inflammation levels have been linked to aging (Sanford, 2017). Sanford (2017) hypothesized that aging in itself is an inherent form of stress that “leads to increased cortisol and catecholamine release, which in turn, results in up-regulation of inflammatory cytokines, such as TNF-alpha and interleukins.” This inherent inflammation has also been known to contribute to the pathogenesis of chronic diseases and cachexia and is associated with reduced food intake (Sanford, 2017). Elevated proinflammatory cytokines alter food consumption in the elderly (Martone et al., 2013; Wysokiński, Sobów, Kloszewska, & Kostka, 2015). For instance, Wysokiński et al. (2015) found that chronic low-grade inflammation may suppress appetite by activating the serotonin system via an increased level of tryptophan. In addition, levels of C-reactive protein (CRP), a substance produced by the liver that increases in the presence of inflammation in the body, are higher with deficient energy intake regardless of whether seniors are free-living or hospitalized; a raised CRP level affects appetite via changes in testosterone levels (Morley & Baumgartner, 2004; Donini, Savina & Cannella, 2003; Kupelian et al., 2010).
Gastrointestinal Tract

One of the significant gastrointestinal changes associated with advancing age is an increase in satiety hormones (which contributes to a reduced dietary intake), such as cholecystokinin (CCK) and peptide YY (PYY), and a decrease in the hunger hormone ghrelin (MacIntosh et al., 2001). Another gastrointestinal change is the delay of gastric emptying that happens with aging, which then results in a more rapid feeling of satiation (MacIntosh et al., 2001). Studies have reported a decreased gastric acid secretion and a slower rate of gastric emptying as people age (Atalayer & Astbury, 2013). This delayed gastric emptying could lead to chronic constipation, which is reported in up to 25% of the population over 65 years of age (MacIntosh et al., 2001). Constipation might cause the individual to feel full, thus, causing a decrease in appetite and intake.

Other studies have reported that in the elderly, increased satiation is predominantly due to signals from the stomach, rather than from other parts of the gastrointestinal tract (MacIntosh, Morley & Chapman, 2002). For instance, it has been shown that the number of sensory nerves in the stomach decrease with aging (Roberts et al., 2007). This reduction leads to a decrease in appetite and slower gastric emptying, which inevitably brings the feeling of early satiation mentioned above. Similarly, the impaired relaxation of the proximal stomach present in the elderly might also cause rapid antral filling and earlier antral stretch, which may contribute to early satiation and sensation of fullness in response to a meal (Wysokiński et al., 2015).
Appetite

Reduced appetite is a primary concern and complaint in the elderly, especially in those of very advanced age and with multiple comorbidities (Rolls, 1996 & Morley, 2013). Studies have reported that older adults experience less hunger and earlier satiety – as they eat smaller meals at a slower rate, drink less, and snack less between meals – when compared to younger people (Atalayer & Astbury, 2013; Wysokiński et al., 2015). For instance, in a study by Wysokiński et al. (2015), when older adults were given a water pre-load, greater satiation was reported, which suggested a failure of the energy-sensing mechanisms.

Additionally, older people do not show the same ability to regulate food intake after prolonged over or underfeeding as young individuals do (Giezenaar et al., 2016; Wysokiński et al., 2015). Atalayer and Astbury (2013) reported that following a period of over-feeding, young men decreased their subsequent meal intakes to accurately compensate for the excess energy while older men were unable to adjust their subsequent meal intakes. This finding indicates that after an anorectic insult (for example, major surgery), “older people are likely to take longer than young adults to regain the weight lost, remain undernourished longer, and be more susceptible to subsequent superimposed illnesses, such as infections.”

All of the studies above demonstrate that appetite changes with aging. However, what causes these changes? The reduction of appetite among the elderly is attributed to multiple factors including olfactory stimuli, nutrients (glucose, amino acids), metabolites (lactate, pyruvate and ketones), and alterations in gut hormones including
cholecystokinin (CCK), glucagon-like peptide -1 (GLP-1) and ghrelin in response to nutrient ingestion (Atalayer & Astbury, 2013; Wysokiński et al., 2015). For instance, in healthy older adults, hunger signals tend to prevail over satiety signals, due to an adapted response up until the ages between 70 and 75. Those signals and adaptive responses may then “contribute to the prolonged satiety and inhibition of hunger after the ages 70-75” (Donini et al., 2003). On the other hand, according to Atalayer and Astbury (2013), the “increases in the satiety signals (i.e., GLP-1) are due to relatively large amounts of fat and the reductions in the acylated to desacylated ratio of ghrelin”, which would lead to decreased hunger in the elderly and a caloric deficit that would eventually result in weight loss. Other studies have shown that neurotransmitters are also altered with age, “resulting in a decline in both hunger and thirst cues” (Roberts et al., 2007).

There is also evidence that as adults advance in their age, there is a decrease in their food intake to counterbalance the reduction in physical activity (PA) and resting metabolic rate (RMR) that occurs with aging due to a decreased opioid (dynorphin) feeding drive and an increase in the satiating effect of CKK (Morley 1996; Morley 2013). Other indirect psychological factors such as bereavement, confusion, depression, and physical factors including limited mobility, inability to feed oneself, and poor dentition or ill-fitting dentures also affect appetite in the elderly (Rolls, 1994 & Landi; Calvani & Tosato, 2016).
Figure 2.1: Factors linked to decreased appetite among older adults

Sensory Function Decline

Multiple studies have described how the perception of the hedonic qualities of food (its odor and taste, specifically) diminish when people get older due to the physiological changes in olfactory and gustatory systems that occur with aging (Wysokiński et al., 2015; Hoffman et al., 2009; Hoffman et al., 2016; Hur et al., 2018; Lui et al., 2016). These changes, in general, result in food being less tasty and less appreciated, “consequently affecting food choice and limiting types and amounts of food eaten” (Wysokiński et al., 2015). Wysokiński et al. (2015) also suggested that the aging changes in the senses are widespread and result from loss of sensory cells, loss of their sensitivity, and poor oral hygiene.
Depression

The death or departure of a spouse, family member, or friend, major illness, financial difficulties, diminished physical capacity, and a change in their neighborhood are some of the social and environmental changes that can accompany old age and that have the potential to lead to depression (Lee, 2016). According to Sanford (2017), there are many causes of depression in older individuals. Some of the causes include loss of spouses and other important loved ones, feelings of loneliness and isolation that often come from living alone, loss of a sense of purpose that may stem from being retired from the workforce or no longer being a primary caregiver to children or an aging spouse, and the overall loss of independence (Sanford, 2017).

Depression can lead to nutritional decline. In the current generation of seniors, cooking, and meal preparation was typically a "female matter" and, for many women, a source of joy (Hays & Roberts, 2006). "When disabilities inhibit the fulfillment of their "duties," some women might feel guilty, frustrated and a sense of loss of their valued role which can dissuade them from cooking and could, therefore, lead to a decline in the quality of foods prepared and consumed" (St.-Onge & Gallagher, 2010). Similarly, males who are accustomed to having meals prepared might fail to thrive if widowed, and may not take an interest in acquiring the kitchen skills to make foods in a manner to which they are accustomed (Atalayer & Astbury, 2013). Sanford (2017) also mentioned that many senior men could even feel that the task of cooking and preparing meals is daunting, which impairs their food intake.
Medications

The number of a person’s co-existing medical conditions generally increases with age. Furthermore, along with an increased number of chronic diseases, comes an increased number of drugs (polypharmacy) (Hays & Roberts, 2006). Some medications may cause side effects, such as loss of appetite or nausea, each of which can affect nutritional status by reducing a person's desire to consume food (St.-Onge & Gallagher, 2010). According to Wysokiński et al. (2015), "appetite-affecting medications include antianxiety agents, antibacterials, antidepressants, antiepileptics, antifungals, antihistamines and decongestants, antihypertensives and cardiac medications, anti-inflammatory, antimigraine, antineoplastics, anti-Parkinson’s disease, and antiviral agents, bronchodilators, CNS stimulants, hypnotics, lipid-lowering agents, muscle relaxants, pancreatic enzyme preparations, smoking cessation aids, and thyroid drugs.”

Medications can also affect nutrient absorption and metabolism and increase nutrient excretion through drug-nutrient interactions or by changing the intestinal flora (Hays & Roberts, 2006).

Oral Health Status

Difficulties in chewing and swallowing, poor oral health (presenting as mouth pain), ill-fitting dentures, and dry mouth are all common among older individuals and can cause discomfort while eating, leading to a restriction of food choices and an increased risk of nutrient deficiency (Hays & Roberts, 2006; Donini et al., 2003). Donini et al. (2003) described that impairments of the masticatory functions, poor dentition, and ill-fitting dentures might influence food choice and limit the type and quantity of
food eaten as a result of altered food choice to circumvent the effort involved in chewing using dentures. There are consistent decreases in the levels of nutrition seen in edentulous individuals as compared to those who have full or partial retention of their teeth (Wysokiński et al., 2015). Lastly, there is also significantly more food avoidance among the subjects with chewing or swallowing problems, discomfort with dentures, or ill-fitting dentures (Wysokiński et al., 2015).

**Introduction to Olfactory Function**

Flavor perception is not only dependent on the input of taste buds, but it is also highly influenced by smell. Olfactory function not only plays a vital role in the detection of hazards in the environment (such as spoiled food, gas leaks, and pollutants), but it is also directly linked to the hedonic pleasure of food (Doets & Kremer, 2016). Moreover, the perception of smell is facilitated by specialized olfactory receptor cells in the nasal cavity, which are exposed to air from the outside environment and protected by a layer of mucus (Schiffman, 1997).

Many factors, such as age, gender, medication, and smoking habits, influence the function of smell in healthy individuals. Among some of the most common causes of smell disorders –some of which could cause permanent loss of smell – are upper respiratory infections, head trauma or injury, and chronic rhinosinusitis (Schiffman, 2002). Furthermore, chronic alcoholism (Rupp, 2004), neurodegenerative diseases such as epilepsy, multiple sclerosis, Alzheimer's disease, and Parkinson's disease, and neuropsychiatric conditions such as attention-deficit Hyperactivity Disorder (ADHD), anxiety, autism, depression, eating disorders and schizophrenia (Field, 2015) are all less
frequent causes that also influence olfactory function. Exposure to various toxic substances such as acrylates, methacrylates, and cadmium from air pollution and chemical exposures often occur in the workplace. These toxins can also cause olfactory loss directly by damaging the smell receptors and indirectly by inducing upper respiratory inflammatory responses or infections (Schiffman, 2002; Doty 2015; Upadhya & Holbrook 2004). According to Glennon et al. (2017), “chronic cigarette exposure could indirectly impair olfactory function via known risk factors, including upper respiratory tract infections, sinonasal problems, and xerostomia.” The authors also established that “smokers appear to be more susceptible to viral respiratory colds, acute and chronic rhinitis, nasal inflammation, and xerostomia, have longer recovery periods after mild traumatic brain injury, and report greater alcohol consumption” (Glennon et al., 2017).

All of those factors have been linked to olfactory dysfunction. Similarly, tobacco smoke is known to have a high amount of cadmium, which has been associated with a long-term decline in the sense of smell.

**Figure 2.2: Factors that can affect smell function among adults**
**Olfactory Function**

According to the Taste and Smell Examination Manual (CDC, 2013), the nasal passages, whose insides are covered with mucous membranes, are dynamic channels for breathing and smell detection. The olfactory mucosa contains millions of neurons that represent sensorial cells with a dendrite projection to the surface epithelium. In turn, these dendrite projections are the ones that hold the non-motile cilia, which have a membrane that is covered with more than 1000 different receptors (Pereira & Van der Bilt, 2016). Because chemical exposure, “bacterial and viral infection, and head trauma membranes affect these nasal passages smell receptors, their amount and placement vary within and between individuals” (Doty, 2003)

As described by Pereira and Van der Bilt (2016), once a chemical component binds to the membrane receptor (G protein, adenylate cyclase – AMPc), the olfactory nerve starts an action potential caused by Na+ and Ca++ influx which conducts information gathered in peripheral receptors to the olfactory bulb. The ionic composition of the mucus layer in the nasal epithelium is modulated by sensory transduction (Pereira & Van der Bilt, 2016). After volatile chemicals are detected in the olfactory bulb, smell signals are delivered directly to the olfactory areas in the brain (Doty, 2003). Moreover, when the olfactory receptors in the posterior region of the nose are activated at the same time as taste buds (when odors from food in the mouth are released in the oral cavity), retronasal smell happens which contributes to the final perception of flavor (Pereira & Van der Bilt, 2016).
**Olfactory Function and Age.** Research has established an association between olfactory loss and aging (Karpa et al., 2010). Evidence of this decrease was presented by Gopinath et al. (2016), who found that Australians with any olfactory impairment were older, more likely to be male and to have a lower BMI. Similarly, Correia et al. (2016) found that the sense of smell was the most affected sense by age and among men in the United States. Toussaint, de Roon, van Campen, Kremer, & Boesveldt (2015) reported a higher prevalence of olfactory impairment among geriatric Dutch individuals (mean = 80.9 years) for anosmia (46.4% vs. 0.3%) and hyposmia (46.4% vs. 31.6%) than in active older adults with a mean age of 67.1 years.

Many factors have been proposed to explain the age-related decline in smell. For instance, some of the responsible factors cited by Doets and Kremmer (2016) were changes in the non-olfactory elements of the nose, olfactory bulb volume and in the grey matter of the brain structures involved in nasal processing, loss of selectivity of receptor cells to odorants, and changes in the transport of neurologic signals (Doty & Kamath, 2014; Patel & Pinto, 2014). There has also been evidence that compared to younger adults, the degree of activation involved in olfactory processing is significantly lower in older individuals. Pereira & van der Bilt (2016) pinpointed that the olfactory epithelium changes with age, which causes it to turn into the non-olfactory epithelium, which could decrease the olfaction capacity.

Moreover, Mojet, Köster, & Prinz (2005) observed that losses in gustatory acuity with age were probably due to declines in olfactory sensitivity since they were resolved when both young and senior subjects wore nose clips. This finding demonstrates that the
sense of taste is more resistant to the detrimental effects of aging than is the sense of smell; thus olfactory symptoms should be evaluated in patients presenting with a complaint of loss of taste (Syed, Hendler & Koncilja, 2016).

A decline in the sense of smell with age can be shown through: “(1) psychophysical tests (i.e. tests of odor detection, identification, discrimination, memory and supra-threshold intensity), (2) electrophysiological tests (i.e. measurements of odor event-related potentials: OERP), and (3) psychophysiological tests (i.e. odor-related changes in heart rate and/or respiration)” (Doty & Kamath, 2014). However, as stated by Doets and Kremer (2016), “these psychophysical tests might not be as useful because odor perception is atypical in normal human behavior and because among the frail and cognitively impaired population,” the results of the test could reflect word and name problems as opposed to olfactory decrements.

Smell Changes Consequences in Older Adults

**Nutritional Effects.** A decline in the sense of smell contributes to reduced intake of food, calories, and nutrients by the elderly (Doets & Kremer, 2016). For example, individuals with impaired olfaction were shown to have lower intakes of protein, folate, magnesium, and phosphorous (Gopinath et al., 2016; Aden et al., 2011). This observation is especially troubling since the literature has also reported that inadequate food intake may lead to unintentional weight loss; estimates show that 5–10% of independently living seniors suffer from undernutrition, and among homecare recipients, the prevalence may rise to 35% in the future (Doets & Kremer, 2016).
Riera and Dillin (2016) cited studies by Albrecht et al. (2009), Cameron, J.D. et al. (2012) and Tong et al. (2011) who investigated the connection between olfactory acuity to the regulation of energy homeostasis, food appreciation, and perception. The authors found that in mice, olfactory sensitivity appears to be dynamically regulated by the nutritional status: before a mealtime, hunger arouses olfactory perception, facilitating the retrieval and ingestion of food. On the other hand, Riera & Dillin (2016) mentioned that the reduction of olfactory sensitivity that is observed after the ingestion of a meal contributes to a satiety response which links endocrine signals to the regulation of olfactory acuity as part of central fasting and feeding circuits (Riera & Dillin, 2016).

**Loss of Enjoyment.** It has been established that for full enjoyment and appreciation of food flavors, a functioning olfactory system is required (Gopinath et al., 2016). Studies have also reported that those with smell deterioration have a lower enjoyment of foods and a change in eating habits (Smoliner et al., 2013; Aschenbrenner et al., 2016), which may lead to decreased motivation to eat (Doets & Kremer, 2016) and thus weight loss (Gopinath et al., 2016). Interestingly, some studies have shown that with an impaired sense of smell, some individuals tend to gain weight rather than lose it because there is (possibly) less reward value from the food that requires eating more food to be satisfied (Patel, DelGaudio & Wise, 2015; NIDCH, 2017). However, it is important to note that many other social and psychological determinants are also potentially involved in the enjoyment of food and should, therefore, be taken into consideration.
Selection of foods. Sergi et al. (2017) emphasized in their review article that a declining smell perception leads to a possible shift towards unhealthy eating habits. Such alteration in the selection of foods was also suggested in the review by Doets and Kremer (2016) who mentioned that an impaired sensory perception of foods might promote the consumption of salt, sugar, and calories to compensate for the lack of sensory stimulation from food and to preserve nutritional status. For instance, a weaker perception of salty or savory flavors may induce people to season their foods with excessive amounts of salt, thereby raising the risk of cardiovascular disease. However, according to Sergi et al. (2017), factors like the soft texture of food, sensory appeal, convenience, and the price could also play a part in making people increase their consumption even when their preference for sweet or salty foods (as tested) remains unchanged. Lastly, the authors highlighted a study by Gopinath et al. (2015), which showed higher consumption of sweet and salty foods as a result of olfactory dysfunction. They hypothesized that said shift could lead to a reduced intake of vegetables and fruits. Those variations could then lead to loss of the protective effects against ischemic heart disease and the risk of ischemic stroke and exacerbation of constipation and dehydration due to low fiber and water intake (Sergi et al., 2017).

Overall, the scientific literature seems to agree that a lack of smell stimulation leads the elderly to choose foods that are considered unhealthy or highly-processed, such as candy, desserts, soda, potato chips, among others (Schiffman & Graham, 2000; van der Meij et al., 2015). One way to counteract these choices might be by enhancing the flavor of foods with the addition of herbs, spices, sauces, and sodium salt of the
amino acid glutamic acid (umami) which can improve food palatability, satisfaction, and salivation in the elderly (Essed et al., 2009; Pouyet et al., 2015).

**Malnutrition.** Malnutrition in older adults has been defined as “undernourishment due to poor dietary intake, consequently leading to involuntary weight loss and muscle wasting (Agarwal et al., 2016).” It is important to note that there is no gold standard for the diagnosis of malnutrition. However, many have found that this condition is characterized by the presence of unintentional weight loss and a suboptimal dietary intake which results in muscle wasting and or loss of subcutaneous fat and/or muscle, or low BMI which could be used as the basis for diagnosis (Agarwal et al., 2016; ICD-10, 2008). Its prevalence increases with age and comorbidities (Agarwal et al., 2016), which makes malnutrition one of the major concerns for the older population.

As mentioned previously, a decreased sense of smell could cause appetite suppression, weight loss, and changes in muscle strength and food selection that could lead to malnutrition (Gopinath et al., 2016; Gopinath, Sue & Kifley, 2012; Seo, Jeon & Hummel, 2009). It is essential to understand the role malnutrition has because of its adverse health consequences in the older population. Malnutrition contributes to “loss of skeletal muscle mass, decreased bone mass, impaired immune function, cognitive decline, poor wound healing, increased hospital admissions, delayed recovery from injury, and increased morbidity and mortality” (Doets & Kremer, 2016).
Handgrip Strength. Handgrip strength plays a “role in the daily lives of people and serves as a reliable proxy indicator of an individual’s hand motor abilities” (Ong et al., 2017). The importance of grip strength relies on the fact that everyday activities require the use of the flexor musculature of the forearms and hands which are involved in gripping strength (Ong et al., 2017). Furthermore, some studies have established handgrip dynamometer to be a valid tool for assessing hand grip strength in older adults (Auyeung et al. 2014). In turn, Ong et al. (2017) cited how handgrip strength measures are useful in that they help researchers identify common age-related disorders such as frailty and sarcopenia (Auyeung et al., 2014, Sayer et al., 2008).

Unintentional weight loss and inadequate food intake (which could be associated to a smell alteration) have also been linked to a decrease in lean muscle and, thus, reduced muscle grip strength (Bales & Richie, 2002). Recent studies have shown that grip strength is a reflection of the quantity of muscle mass and overall health status (Musalek & Kirchengast, 2017). However, according to Ge et al. (2016), other factors such as long age-related carpal and digital exostosis (commonly referred as bony spur or osteoma, it occurs when a bony growth extend beyond a bone's usual smooth surface) could help explain the decreased grip strength seen with increasing age.

National Health and Nutrition Examination Survey (NHANES)

What is NHANES?

The National Health and Nutrition Examination Survey (NHANES) is a health-related program conducted by the CDC and National Center of Health Statistics that collects the health examination data for a nationally-representative sample of the
resident, non-institutionalized U.S population (CDC, 2018). Exclusion criteria for the participation on the survey are any "persons in supervised care or custody in institutional settings, all active-duty military personnel, active-duty family members living overseas, and any other U.S. citizens residing outside of the 50 states and District of Columbia" (CDC, 2018). The NHANES survey consists of questionnaires administered in the home, followed by a standardized health examination in specially equipped mobile examination centers (MEC) (Johnson et al., 2014).

The data collection starts with a household screener, followed by an interview and an examination that includes the objectives measures of health status. In the interview, information from the participant’s demographics, household, health, and nutrition is collected (Johnson et al., 2014). The last part of the examination component is the physical measurements and laboratory testing (Johnson et al., 2014). These measured are conducted on MECS. NHANES has three separate MECs; two are in operation at study locations, while the third one is being prepared for operation or traveling to a new site (Johnson et al., 2014).

Moreover, surveyors have hypothesized that one of the factors thought to be responsible for increased household response rates in the last surveys is the fact that each person was given remuneration for his or her time and participation, and that the location of MEC was arranged in such a way that required less traveling time (Johnson et al., 2014). Some of the recruitment for the participation of the study included a press kit with a press release, the NHANES overview brochure, and other NHANES materials, which was sent to local media outlets and newspapers, in addition to an open house for
possible participants (Johnson et al., 2014).

The survey oversamples some population groups for increased reliability and precision of estimates on the indicators of the health status for the population subgroups (Johnson et al., 2014). For the survey cycle of 2011-2014, in addition to the ongoing oversampling of Hispanics, non-Hispanic blacks, older adults, and low-income white and other persons, Asians were oversampled. On the other hand, the weighting schemes of the survey allowed for subgroups estimates to be combined in order to obtain national estimates that could reflect the relative proportions of these groups in the whole population (CDC, 2018); they also ensured that calculated estimates are an accurate representation of the U.S. civilian non-institutionalized population (Johnson et al., 2014).

According to the NHANES Sample Design Manual, some of the survey objectives are to (1) "estimate the number and percentage of persons in the U.S population and design subgroups with selected diseases and risk factors; (2) monitor trends in the prevalence, awareness, treatments, and control of selected diseases; (3) monitor trends in risk behaviors and environmental exposures (4) study the relationship among diet, nutrition, and health; (5) explore emerging public health issues and new technologies; (6) provide baseline health characteristics that can be linked to mortality data from national death index or other administrative records enrollment and claims data from the Center for Medicare and Medicaid Services (Johnson et al., 2014)."
History of NHANES

NHANES was established in 1959 with the first National Health Examination Survey (NHES I) conducted (CDC, 2018). The focus was on selected chronic diseases, such as cardiovascular disease and diabetes (Zipf et al., 2013). Since then, the survey has been conducted in three separate eras: the National Health Examination Survey (NHES) era (1959–1970), the periodic and population-specific NHANES era (1971–1994), and the continuous NHANES era from 1999–present (Zipf et al., 2013). One of the significant changes happened in 1971 when a nutrition component was added to the survey, and the survey name changed to the National Health and Nutrition Examination Survey. This survey also began the periodic and population-specific era (1971–1994), during which four surveys were conducted. The first NHANES (NHANES I) was conducted from 1971 to 1974, and it focused on the health of participants aged 1–74 (Zipf et al., 2013). The second NHANES (NHANES II) was conducted during 1976–1980, where the age of the eligible participants started at six months, and it focused on nutrition and health (Zipf et al., 2013). Another change happened in 1982–1984 when NHANES shifted to a population-specific survey. The Hispanic Health and Nutrition Examination Survey (HHANES), which aimed to produce estimates of nutrition and health status for these subgroups, is an example of that change. Since 1999, NHANES has become a continuous, ongoing annual survey of the non-institutionalized civilian resident population of the United States (Zipf et al., 2013).
Overview of NHANES Sample Design

Response rate varies by year, but NHANES estimates that an average 10,500 people out of 12,000 complete the interview, and 10,000 go to the MEC for each of the 2-year cycles (CDC, 2018). The surveyors can increase the likelihood of attending the MEC by minimizing the amount of travel required for a sampled participant to visit a MEC (Zipf et al., 2013; Johnson et al., 2014). Additionally, NHANES participation is voluntary and has two stages: the home interview and the health examination. Before the home interview, sample persons are informed of the survey process and their rights as a participant by interviewers and with written materials, such as brochures and flyers.

A four-stage sample design was used in NHANES 2011–2014 (Zipf et al., 2013; Johnson et al., 2014). Stage one consisted of selecting primary sampling units (PSUs) from a frame of all U.S. counties. PSUs were mostly counties and were selected with probabilities proportionate to a measure of size (PPS). Secondly, a sample of area segments, comprising census blocks or combinations of blocks were created. Thirdly, following the selection of segments, a listing of all dwelling units (DUs), including non-institutional group residences such as dormitories in the sampled segments was prepared, and a sub-sample of these were designated for screening to identify potential test participants. Finally, sub-sampling rates were set up to produce a national, approximately equal probability sample of households. All eligible members within a home were listed, and a sub-sample of individuals was selected based on sex, age, race and Hispanic origin, and income. The sub-sampling rates and designation of potential sampled participants within screened households were arranged to provide
approximately self-weighting samples for each subdomain and to maximize the average number of tested participants per sample household (CDC, 2018).

**Mobile Examination Center (MEC).** The data were collected in a standardized environment to minimize the occurrence of site-specific errors. Each MEC was a group of four trailers set up side by side and connected by an enclosed passageway; they varied in size depending on the requirements of the component (Zipf et al., 2013). The examination lasted anywhere from 40 minutes to 4 hours, and the examination was contingent on the age and gender of the participant. An appointment for an examination in MEC was scheduled by the interviewer who called the field office and was then randomly assigned to a morning, afternoon or evening appointment (Zipf et al., 2013, Johnson et al., 2014).

**Household interview.** The NHANES household interview occurred in the participants’ home and consisted of: the screener questionnaire, relationship questionnaire, sample participant questionnaire, and family questionnaire (Zipf et al., 2013).

**Screener.** Before the initial interview, the participants were sent a letter with a computer-generated message introducing and providing information about NHANES and the sex, age, race or ethnicity that was necessary for the study (Zipf et al., 2013). The screening occurred, most of the time, on the doorstep after the selection of those who were sent the letter and responded; the aim was to determine eligibility to participate further in NHANES (Johnson et al., 2014). If a participant from that household was eligible and met the criteria of NHANES, the interviewer proceeded with
the relationship questionnaire that divided household residents into individual family units (Johnson et al., 2014). Some of the reasons that prevented an interviewer from completing the screener questions were: a "vacant unit or residence, address not qualifying as a dwelling unit, non-existent sampled dwelling unit and or refusal to participate from a household resident" (CDC, 2018).

**Hypotheses**

1. Smell function decreases with age.
   a) This change could be related to smoking, socio-economic status, education, demographics, among other factors.

2. It is expected that the decline in smell will, inevitably, decrease food intake and the quality of life which will lead to, and be reflected, in weight and appetite loss, decreased muscle grip strength, physical functioning and activity, and poor self-rated health.

**Objectives**

1. Investigate the prevalence and risk factors associated with smell disorders in older adults

2. Understand the effect that a smell alteration or impairment has on the health status of older adults in the U.S by investigating weight changes, appetite, handgrip strength, physical functioning and activity, and self-rated health.
CHAPTER 3
MATERIALS AND METHODS

Study Population

To investigate the prevalence of smell impairment among older adults and its association with health status, we used a representative dataset collected from NHANES 2013-2014 (CDC, 2018). NHANES 2013–2014 collected questionnaire data and clinical measures from a nationally representative sample of the civilian, non-institutionalized U.S. population, who were identified using multistage, stratified probability sampling 2014 (CDC, 2018). Since the data was already de-identified and was publicly available, this study was exempt from institutional review board appraisal.

Participants

In 2013-2014, the National Center for Health Statistics collected data from NHANES, which assessed the health and nutritional status of people in the USA from 30 different survey locations. For that cycle, 14,332 persons were selected, of whom 10,175 completed the interview and 9,813 were examined. All participants were given a cash payment of $5.00 as a “thank-you” for their time and effort. NHANES also gave participants compensation for transportation and infant or elder care.

Examination Components

The primary objective of this research was to understand the age-related alterations in smell. For that reason, we chose to focus on analyzing variables from the NHANES smell examination component and questionnaire, which will be referred to as the smell disorder assessment. In addition, sociodemographic variables were assessed
to study the contributing and risk factors for a decline in smell. Furthermore, to understand the effect that smell impairment has on health, we chose variables from different NHANES datasets that reflect the health of an individual; said variables will be referred to as health assessment variables. These variables included height, weight, BMI, weight changes (short-term and long-term), and handgrip strength.

**Exclusion and Inclusion Criteria**

First, the 2013-2014 NHANES datasets were merged for a total of 10,175 individuals (Figure 3.1). We excluded those records for people below age 60, which reduced the sample size to 1841 individuals. Then we excluded those 56 persons who had not completed both the MEC and home interview, which cut the sample to 1785 participants. Lastly, we excluded 372 individuals who did not complete the scent test in its entirety and the 126 persons who did not complete the grip test or had hand surgery. The final analytical sample for this study consisted of 1287 adults, aged over 60 years, who answered the CSQ (Smell and Taste Questionnaire) and CSX (Smell and Taste Examination Component) with a response rate of 99.9% and completed the handgrip test (MGDEXTST). Table 3.1 shows the number of individuals who had reported having surgery on their hands or wrists.

Variables were classified into two categories: sociodemographic characteristics and health assessment. If multiple variables that could be used in the analysis were identified from the data set, only those variables felt to be most closely linked to the construct under study were retained. Frequency distributions for all variables were extracted and examined from the full study database, and where data were sparse or
had more than 10% missing values, variable categories were excluded or re-coded.

The complete questionnaire, codebook, and data are publicly available online (CDC, 2018). Answers of “refusal” and “don’t know” were coded as missing values (.). Missing values were excluded from the sample. Completed original coding and missing variables used for each of the examination components are listed in Appendices A and B.

Figure 3.1 Inclusion criteria for the study sample and the number of participants

\[ MEC^a = \text{Mobile Examination Center} \]
Table 3.1 Distribution of participants who reported hand surgery.

<table>
<thead>
<tr>
<th>Ever had surgery on hands or wrists?</th>
<th>Response</th>
<th>Number</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No</td>
<td>1195</td>
<td>92.92</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>91</td>
<td>7.08</td>
</tr>
</tbody>
</table>

Smell Disorder Assessment

Taste and Smell Examination Component. The Taste and Smell Examination of NHANES was designed to provide "normative reference data for the ability to smell and taste in the U.S. adult population" (CDC, 2013). The NHANES taste and smell examination protocol consisted of the eight-item Modified Pocket Smell Test (Pocket Smell Tests™, Sensonics, Inc., Haddon Heights, NJ) and taste testing for salt and bitter tastes. The odor identification test assesses odor threshold tasks and suprathreshold olfactory measures (e.g., discrimination, odor intensity) and is considered to be a rapid and accurate method for detecting olfactory dysfunction (Cain & Rabin, 1989). A household interview questionnaire was also administered by trained NHANES staff to assess personal health history data for taste and smell disorders. The examination component of NHANES was focused on smell (and not taste) because it is a sensory problem for the majority of population (CDC, 2013). From this dataset, we chose only the variables related to smell.

NHANES Eligibility Criteria for the Taste and Smell Examination. The smell examinations were conducted on adults 40 years and older who were not pregnant or lactating.
Overview of the Taste and Smell Examination. The Taste and Smell Examination Manual (CDC, 2013) listed the six parts of the taste and smell examination (CSX).

1. Pre-examination Screening Questions: Before the examination, exclusion questions were asked. After the exclusion criteria were established, a short series of questions were asked to screen the participants for conditions that may influence the test results, such as a head cold or sinus problem. The purpose of those additional (short) series of questions was to help distinguish the prevalence of temporary vs. permanent loss of taste or smell (CDC, 2013).

2. Explanation of the Smell and Taste Exam Item Rating Scale: Before the test, the participants were taught how to use the Generalized Labeled Magnitude Scale, or gLMS, rating scale (Bartoshuk et al., 2004). Then, they practiced by rating two lights presented on an LED screen. Afterward, participants rated the brightness of a standard series of three lights presented to them (a dim, a moderate, and bright light). If the results were in the correct order on the gLMS scale, they proceeded with the tasting exam. Otherwise, they did not do the taste testing but continued to do the smell testing (CDC, 2013).

3. Taste Examination Test Section: None of the variables from this section were selected.

4. The Odor Identification Test Section: The Modified Pocket Smell Test (M-PST) was an eight-item self-administered "scratch and sniff" test (Pocket Smell Tests™, Sensonics, Inc., Haddon Heights, NJ) consisting of two four-item Pocket Smell Tests which were used in parallel (Doty, Shaman & Dann, 1984; Rawal et al.,
The test odorants were embedded in microcapsules positioned on scent strips at the bottom and top of each page of the test cards (Doty, Shaman & Dann, 1984). For the stimuli to be released, the participant had to scratch it with a plastic stylus tip. When the stimuli was smelled, the participants were asked to identify the smell out of the four given choices presented (Doty, 1995; Doty, 2009). The subjects were still required to choose one of the four choices as an answer even when they could not identify any odor when presented with the odorant (Doty, 1995; Doty, 2009). The logic behind this practice is that it is thought that some residual ability to smell may remain even if an individual is unaware of the loss of smell.

5. The Salt Replicate Test Section: None of the variables from this section were selected.

6. Taste and Smell Questionnaire (CSQ): NHANES household interview questionnaire collected data on the prevalence of self-reported taste and smell problems, a previous history of medical treatment for taste and smell disorders, and data on medical conditions that increase the likelihood of smell and taste disorders to coordinate with the examination component. According to the Taste and Smell Examination Manual (2013), the CSQ was “content-validated by chemosensory experts and tested for response problems and cultural appropriateness” (Hoffman et al., 1998; Hoffman et al., 2016; Murphy et al., 2002; Rawal et al., 2015). Using the Computer-Assisted Personal Interviewing (CAPI) system, the questionnaire was administered at home by trained interviewers (Rawal et al.,
The overall purpose of the said questionnaire was to provide data to support the Healthy People 2020 objectives for taste and smell disorders (Healthy People 2020, 2009). Only variables related to smell were chosen.

**Smell Variables.** Table 3.2 shows the variables chosen for the smell examination and questionnaire component of NHANES 2013-2014 (CSX and CSQ). All the variables below were extrapolated from the smell examination component dataset.

- **Scent Test Total Score.** Each scent from the Odor Identification Test Section (chocolate, strawberry, smoke, leather, soap, grape, onion and natural gas) was re-coded as ‘wrong’ if the participants could not identify the smell, or as ‘right’ if the scent was identified; each correct answer was summed, which gave us the scent test total score. The scent test total score ranged from zero to eight.

- **Smell Impairment.** The participants were categorized as smell impaired (‘SI Present’) if their total scent score was less or equal than five, meaning that the participants were only able to identify five or less of the smells correctly (Hoffman et al., 2016).

- **Smell Alteration Total Score.** The score was calculated from the sum of all of the affirmative answers (‘yes’) to the following variables: a problem in smell in the past 12 months (CSQ010), a worse sense of smell since age 25 (CSQ_change), or smelling an unpleasant, bad, or burning odor when nothing is there (CSQ040). The score ranged from zero to three.
Smell Alteration. Participants were categorized as having smell alteration (‘SA Present’) if their smell alteration score was greater or equal to one, meaning that they had a problem in smell in the past 12 months (yes/no), worse sense of smell since age 25 (changed/no change), or smelling an unpleasant, bad, or burning odor when nothing is there (yes/no) (Hoffman et al., 2016).

Other Factors Measured.

Socio-Demographic Characteristics. Sociodemographic information including gender, age (60-64, 65-69, 70-74, and >74), race/ethnicity (Non-Hispanic (NH) White, Non-Hispanic Black, Mexican-American, Other Hispanic or Other Race), education level (high school or less, or college or more), and income to poverty ratio (<1.2, 1.2-2.1, 2.2-3.9 or >3.9), and cohabitation status (living with someone or living alone) was collected for each respondent from the Demographics dataset (DEMO). Income to poverty ratio was calculated as the ratio of family income to the poverty threshold and placed into one of four categories. The variable of smoking (SMQ020) was extracted from the Smoking-Cigarette Use dataset (SMQ). Smoking was defined as answering ‘yes’ if the participants had ‘smoked at least 100 cigarettes in life’.
Table 3.2 Smell examination variables, coding, and labeling\textsuperscript{a}

<table>
<thead>
<tr>
<th>Label</th>
<th>Coding/ Meaning</th>
<th>Variable Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall Taste &amp; Smell Exam Status</td>
<td></td>
<td>CSXEXSTS</td>
</tr>
<tr>
<td>1 Complete</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Partial</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Not done</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chocolate Scent Smell Test</td>
<td>0 Wrong</td>
<td>choco_ST</td>
</tr>
<tr>
<td>1 Correct</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strawberry Scent Smell Test</td>
<td>0 Wrong</td>
<td>straw_ST</td>
</tr>
<tr>
<td>1 Correct</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Smoke Scent Smell Test</td>
<td>0 Wrong</td>
<td>smoke_ST</td>
</tr>
<tr>
<td>1 Correct</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leather Scent Smell Test</td>
<td>0 Wrong</td>
<td>leather_ST</td>
</tr>
<tr>
<td>1 Correct</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soap Scent Smell Test</td>
<td>0 Wrong</td>
<td>soap_ST</td>
</tr>
<tr>
<td>1 Correct</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grape Scent Smell Test</td>
<td>0 Wrong</td>
<td>grape_ST</td>
</tr>
<tr>
<td>1 Correct</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Onion Scent Smell Test</td>
<td>0 Wrong</td>
<td>onion_ST</td>
</tr>
<tr>
<td>1 Correct</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Natural Gas Scent Smell Test</td>
<td>0 Wrong</td>
<td>gas_ST</td>
</tr>
<tr>
<td>1 Correct</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scent Test Total Score</td>
<td>0-8 Range of Values</td>
<td>ST_totals</td>
</tr>
<tr>
<td>Presence of Smell Impairment</td>
<td>0 No SI (&gt;5 correct)</td>
<td>smell_imp</td>
</tr>
<tr>
<td>1 SI Present (≤5 correct)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\textsuperscript{a}SI = smell impairment.
Table 3.3 Study sample socio-demographic variables, coding and label

<table>
<thead>
<tr>
<th>Label</th>
<th>Code</th>
<th>Meaning</th>
<th>Variable Name</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Demographics (Demo)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>1</td>
<td>Male</td>
<td>gender</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Female</td>
<td></td>
</tr>
<tr>
<td>Age Categories</td>
<td>1</td>
<td>60-64</td>
<td>Agecat</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>65-69</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>70-74</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>&gt;74 (75-80)</td>
<td></td>
</tr>
<tr>
<td>Race</td>
<td>1</td>
<td>Mexican American</td>
<td>RIDRETH1</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Other Hispanic</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>NH\textsuperscript{a} White</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>NH Black</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>Other race</td>
<td></td>
</tr>
<tr>
<td>Education/ Level of Education</td>
<td>0</td>
<td>High School or less</td>
<td>Educ</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>College or more</td>
<td></td>
</tr>
<tr>
<td>Income/'Income to poverty ratio'</td>
<td>1</td>
<td>&lt;1.2</td>
<td>Income</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>1.2-2.1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>2.2-3.9</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>&gt;3.9</td>
<td></td>
</tr>
<tr>
<td>Cohabitation Status</td>
<td>1</td>
<td>Living with someone</td>
<td>marital_status</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Living alone</td>
<td></td>
</tr>
<tr>
<td>Interview/Examination status</td>
<td>1</td>
<td>Interviewed only</td>
<td>RIDSTATR</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Both interviewed and MEC examined</td>
<td></td>
</tr>
<tr>
<td>Smoking-Cigarette Use (SMQ)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Smoked at least 100 cigarettes in life</td>
<td>1</td>
<td>Yes</td>
<td>SMQ020</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>No</td>
<td></td>
</tr>
</tbody>
</table>

\textsuperscript{a}NH= Non-Hispanic
Health Assessment Variables.

**Weight.** For the weight-related variables, we used the Weight History (WHQ) dataset from NHANES (NHANES, 2016). The weight history section provided personal interview data on several topics related to body weight, including self-perception of weight, self-reported weight over the participant's lifetime, attempted weight loss during the past 12 months, and methods used to try to lose weight and to keep from gaining weight. Table 3.4 shows the variables chosen and extrapolated from this dataset.

Weight and height were measured at the time of physical examination in the MEC. The measurements followed standard procedures and were carried out by trained technicians using standardized equipment. BMI was calculated as weight in kg/(height in meters)$^2$, and categorized into standard BMI categories: underweight (<18.5 kg/m$^2$), normal weight (18.5 to 24.9 kg/m$^2$), overweight (25-29.9 kg/m$^2$), and obese (>30.0 kg/m$^2$).

One-year and ten-year weight changes were calculated by subtracting the participants self-reported 'weight 1 year ago in kg' or 'weight 10 years ago in kg' from the 'current weight in kg.' If the total from the subtraction was negative, the participants lost weight ('decreased' category), if the value was positive the subject gained weight ('increased' category) and a value of zero meant 'no change' in weight.
Table 3.4 Weight history variables, coding, and label of the study sample (WHQ)

<table>
<thead>
<tr>
<th>Label</th>
<th>Code</th>
<th>Meaning</th>
<th>Variable Name&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BMI Categories</strong></td>
<td>1</td>
<td>Underweight (&lt;18.5 kg/m^2)</td>
<td>BMIcat</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Normal (18.5-24.9 kg/m^2)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Overweight (25-29.9 kg/m^2)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Obese (&gt;30 kg/m^2)</td>
<td></td>
</tr>
<tr>
<td><strong>BMI</strong></td>
<td></td>
<td>Range of Values</td>
<td>BMI</td>
</tr>
<tr>
<td><strong>Height in m^2</strong></td>
<td></td>
<td>Range of Values</td>
<td>height</td>
</tr>
<tr>
<td><strong>Current Weight in kg</strong></td>
<td></td>
<td>Range of Values</td>
<td>currentweight</td>
</tr>
<tr>
<td><strong>Weight 1 year ago in kg</strong></td>
<td></td>
<td>Range of Values</td>
<td>weight1_kg</td>
</tr>
<tr>
<td><strong>Weight 10 years ago in kg</strong></td>
<td></td>
<td>Range of Values</td>
<td>weight10_kg</td>
</tr>
<tr>
<td><strong>One-Year Weight Change</strong></td>
<td>0</td>
<td>No change</td>
<td>WC1y_cat</td>
</tr>
<tr>
<td>(Categories)</td>
<td>1</td>
<td>Decrease</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Increase</td>
<td></td>
</tr>
<tr>
<td><strong>Ten-Year Weight Change</strong></td>
<td>0</td>
<td>No Change</td>
<td>WC10y_cat</td>
</tr>
<tr>
<td>(Categories)</td>
<td>1</td>
<td>Decrease</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Increase</td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup>Variable Name used for SAS.

**Handgrip Strength.** According to the Muscle Strength Examination Manual (CDC, 2011), the muscle strength/grip test measured the isometric grip strength using a handgrip dynamometer. The participants were excluded from the analysis if they were <6 years old and if they were unable to hold the dynamometer with both hands (e.g., missing both arms, both hands, thumbs on both hands, or paralyzed in both hands) (CDC, 2011). If a participant was able to grip the dynamometer with one hand, they still performed the test. Lastly, those who had surgery on either hand or wrist in the last three months were not tested on that particular hand (CDC, 2011).
A detailed description of testing procedures can be found in the NHANES Muscle Strength Procedures Manual (2011). Briefly, the Takei digital dynamometer (Model T.K.K. 5401, Takei Scientific Instruments Co., Ltd., Niigata, Japan) was calibrated until the second joint of the participant’s index finger was at a 90-degree angle on the handle. Participants were instructed to maintain a proper stance, standing with their feet hip-width apart and even, toes pointing forward, knees comfortable but not bent, shoulders back and chest up, eyes straight ahead, shoulder abducted, straight arm downside, elbow fully extended, and wrist in a neutral position.

For the formal testing, participants were asked to squeeze the dynamometer as hard as they could with each hand while in a standing position with the elbow fully extended at the side. Each hand was tested three times while the participant was in the standing position unless the participant was physically limited, alternating hands between trials with a 60-second rest between measurements on the same side.

Table 3.5 shows all the variables chosen and extrapolated from the muscle strength examination dataset. The average of the three handgrip strength measurements on the dominant hand was used as the handgrip strength. The hand for the grip test was determined from variable MGATHAND; if the individual started with the right hand and he was left-handed, ‘hand 2’ variables were chosen for the average (MGXH2T1, MGXH2T12, MGXH2T3). By self-report, 90.0% of the persons in the sample had a dominant right hand (Table 3.6). For those who were ambidextrous, the highest average of the two hands were used.
From the values of average handgrip strength, a new variable was extrapolated: muscle strength categories. Each individual was classified as having normal or below normal strength (Table 3.5), based on the Foundation for the National Institutes of Health (FNIH) criteria, which was used to provide national estimates of the muscle strength of older adults in the U.S in 2011–2012 (Studenski et al., 2014; Looker & Wang, 2014). Based on the maximum handgrip strength, the FNIH Sarcopenia Project developed these sex-specific criteria to diagnose different degrees of muscle strength (i.e., weak, intermediate, and normal) in the older population (Studenski et al., 2014; Alley et al., 2014). Moreover, Alley et al. (2014) mentioned that these thresholds are related to the level of muscle weakness that is associated with slow gait speed, which is a vital mobility impairment.

For analytical purposes, we dichotomized muscle strength categories into normal muscle strength (>32 kg for men and >20 kg for women) or below normal muscle strength (<32 kg for men and <20 kg for women) to understand where the older adults in our studies fell with respect to the diagnostic criteria.
Table 3.5 Muscle Strength/Grip test (MGX) examination variables’ label, meaning, and name for the study sample

<table>
<thead>
<tr>
<th>Label</th>
<th>Code</th>
<th>Meaning</th>
<th>Variable Name&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grip test status</td>
<td>0</td>
<td>Incomplete</td>
<td>MGDEXSTS</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>Complete</td>
<td></td>
</tr>
<tr>
<td>Begin the test with this hand&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1</td>
<td>Right</td>
<td>MGATHAND</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Left</td>
<td></td>
</tr>
<tr>
<td>Grip strength (kg), hand 1, test 1</td>
<td></td>
<td>Range of Values</td>
<td>MGXH1T1</td>
</tr>
<tr>
<td>Grip strength (kg), hand 2, test 1</td>
<td></td>
<td>Range of Values</td>
<td>MGXH2T1</td>
</tr>
<tr>
<td>Grip strength (kg), hand 1, test 2</td>
<td></td>
<td>Range of Values</td>
<td>MGXH1T2</td>
</tr>
<tr>
<td>Grip strength (kg), hand 2, test 2</td>
<td></td>
<td>Range of Values</td>
<td>MGXH1T2</td>
</tr>
<tr>
<td>Grip strength (kg), hand 1, test 3</td>
<td></td>
<td>Range of Values</td>
<td>MGXH1T3</td>
</tr>
<tr>
<td>Grip strength (kg), hand 2, test 3</td>
<td></td>
<td>Range of Values</td>
<td>MGXH2T3</td>
</tr>
<tr>
<td>Ever had surgery on hands or wrists?</td>
<td>1</td>
<td>Yes</td>
<td>MGD050</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Dominant hand</td>
<td>1</td>
<td>Right</td>
<td>MGD130</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Left</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Both</td>
<td></td>
</tr>
<tr>
<td>Average Hand Grip Test (kg)</td>
<td></td>
<td>Range of Values</td>
<td>dominanthond_gt</td>
</tr>
<tr>
<td>Muscle Strength Test Categories</td>
<td>1</td>
<td>Normal&lt;sup&gt;c&lt;/sup&gt;</td>
<td>musclest_cat2</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>Below Normal&lt;sup&gt;d&lt;/sup&gt;</td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup>Variable Name used for SAS.
<sup>b</sup>Normal= >32kg for men & >20kg for women
<sup>c</sup>Hand the participant used for grip strength= ’Hand 1’
<sup>d</sup>Below Normal= <32kg for men & <20kg for women
Table 3.6 Distribution of participants’ dominant hand

<table>
<thead>
<tr>
<th>Dominant Hand</th>
<th>N</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right</td>
<td>1158</td>
<td>89.98</td>
</tr>
<tr>
<td>Left</td>
<td>93</td>
<td>7.23</td>
</tr>
<tr>
<td>Ambidextrous</td>
<td>36</td>
<td>2.8</td>
</tr>
</tbody>
</table>

Physical Activity and Functioning. Physical activity was calculated from the work and recreational variables (Table 3.7) of the Physical Activity Questionnaire (PAQ) (NHANES, 2017). Figure 3.2 shows the criteria used for the classification of vigorous or moderate active at work or recreationally and walking or biking variables. The participant was classified as physically active (variable name=person_active) if they responded ‘yes’ to any of the following variables: vigorous work activity, moderate work activity, participant walked or biked, moderate recreational activity and vigorous recreational activity.

We also evaluated the hours of sedentary activity which was calculated from the variable PAD680 (minutes of sedentary activity). The variable of sedentary activity was defined as all the hours that the participants spend sitting at work or at home, including time spent sitting at a desk, traveling in a car or bus, reading, playing cards, watching television, or using a computer (NHANES, 2017). Time spent sleeping did not count as sedentary hours.
Instrumental Activities of Daily Living (IADL) impairment was calculated from these variables: difficulty in dressing, difficulty getting in and out of bed, difficulty preparing meals, difficulty managing money, and difficulty with house chores (Vasquez et al. 2014). For each IADL, the subjects who reported that performing the activity was ‘somewhat’/‘very difficult’ or who reported receiving help with the activity were classified as having ‘difficulty.’ Those who reported performing the activity by themselves with no difficulty were classified as having ‘no difficulty.’ The number of IADLs for which each subject reported having ‘difficulty’ was summed to yield an index score (Vasquez et al., 2014). Those who reported ‘difficulty’ for one or more activity were coded as ‘1’ (‘IADL impaired’); otherwise, they were coded as ‘0’ because they did not have an IADL impairment (Vasquez et al., 2014).
Table 3.7 Physical activity and functioning variables’ label, meaning, and name for the study sample

<table>
<thead>
<tr>
<th>Label</th>
<th>Code</th>
<th>Meaning</th>
<th>Variable Name&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Physical Activity (PAQ)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vigorous work activity</td>
<td>1</td>
<td>Yes</td>
<td>PAQ605</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Moderate work activity</td>
<td>1</td>
<td>Yes</td>
<td>PAQ620</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Minutes sedentary activity</td>
<td></td>
<td>Range of Values</td>
<td>PAD680</td>
</tr>
<tr>
<td>Walk or bicycle</td>
<td>1</td>
<td>Yes</td>
<td>PAQ635</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Moderate recreational activity</td>
<td>1</td>
<td>Yes</td>
<td>PAQ605</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Vigorous recreational activity</td>
<td>1</td>
<td>Yes</td>
<td>PAQ650</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Hours of sedentary activity</td>
<td>1-18</td>
<td>Range of Values</td>
<td>hours_sedentary</td>
</tr>
<tr>
<td>Is the participant recreationally and or work active?</td>
<td>1</td>
<td>Active</td>
<td>person_active</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>Not Active</td>
<td></td>
</tr>
<tr>
<td><strong>Physical Functioning (PFQ)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Presence of IADL&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1</td>
<td>IADL Impaired</td>
<td>IADL_imp</td>
</tr>
<tr>
<td>Impairment/IADL impaired</td>
<td>0</td>
<td>Not Impaired</td>
<td></td>
</tr>
<tr>
<td>House chore difficulty</td>
<td>1</td>
<td>Difficulty</td>
<td>PFQ061F2</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>No Difficulty</td>
<td></td>
</tr>
<tr>
<td>Managing money difficulty</td>
<td>1</td>
<td>Difficulty</td>
<td>PFQ061A2</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>No Difficulty</td>
<td></td>
</tr>
<tr>
<td>Preparing meals difficulty</td>
<td>1</td>
<td>Difficulty</td>
<td>PFQ061G2</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>No Difficulty</td>
<td></td>
</tr>
<tr>
<td>Getting in and out of bed difficulty</td>
<td>1</td>
<td>Difficulty</td>
<td>PFQ061J2</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>No Difficulty</td>
<td></td>
</tr>
<tr>
<td>Dressing yourself difficulty</td>
<td>1</td>
<td>Difficulty</td>
<td>PFQ061L2</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>No Difficulty</td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup>Variable Name used for SAS.

<sup>b</sup>IADL= Instrumental Activities of Daily Living
Self-Rated Health Assessment. The variable self-rated health was chosen from the Hospital Utilization & Access to Care (HUQ) Questionnaire (NHANES, 2015). Subjects were asked to rate their current health status into one of the six response categories: 1) excellent, 2) very good, 3) good, 4) fair, 5) poor, and 6) very poor. The ‘excellent,’ ‘very good’ and ‘good’ categories were combined, as were the ‘poor’ and ‘very poor’ categories to ensure that a sufficient number of subjects were contained in each category.

Table 3.8 Self-Rated health variable coding and labeling

<table>
<thead>
<tr>
<th>Label</th>
<th>Meaning</th>
<th>Namea</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-Rated Health Condition/Rated Health</td>
<td>1 Excellent/VG/Good</td>
<td>rated_health</td>
</tr>
<tr>
<td></td>
<td>2 Fair</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3 Very poor/Poor</td>
<td></td>
</tr>
</tbody>
</table>

a Variable Name used for SAS.

Poor Appetite or Overeating. Appetite changes were calculated from the Mental Health-Depression Screener (DPQ) Questionnaire (NHANES, 2016). Participants were coded as ‘yes’ if they reported the presence of poor appetite or overeating in the prior two weeks. The original scale was: 0 = ‘not at all’, 1 = ‘several days’, 2 = ‘more than half the days’, 3 = ‘nearly every day’, 7 = ‘refused to answer’, 9 = ‘did not know’. Ideally, these appetite issues would have been asked separately instead of together.

Table 3.9 Presence of poor appetite or overeating (appetite) variable, coding and labeling

<table>
<thead>
<tr>
<th>Label</th>
<th>Meaning</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Presence of Poor Appetite or Overeating/Appetite</td>
<td>1 Yes</td>
<td>appetite</td>
</tr>
<tr>
<td></td>
<td>0 No</td>
<td></td>
</tr>
</tbody>
</table>
CHAPTER 4

STATISTICAL ANALYSES

Statistical analyses were accomplished using SAS software version 9.4 (SAS Institute, Cary, NC, USA). We employed sample weights to account for unequal probabilities of selection, nonresponse bias, and oversampling of specific subgroups in NHANES 2013–2014 because the demographics of the people sampled for NHANES did not represent the entire United States population (CDC, 2018; Rasmussen et al. 2018). Differences among groups were established using two-sample t-tests for parametric data. The Wilcoxon rank sum test was used to compare non-parametric data, and the chi-squared test was used with categorical measures (Rawal et al., 2016).

A simple logistic regression analysis was conducted for each variable to generate an odds ratio (OR). The 95% confidence intervals were generated for each OR. A confidence interval (CI) that did not contain 1 (unity) indicated a statistically significant result at the 95% confidence level (Greenland et al., 2016; Rawal et al., 2016). The statistical significance was reflected by the p-value obtained from the likelihood ratio test obtained from the logistic regression output in SAS. P-values below or equal to 0.05 were considered statistically significant (Greenland et al., 2016; Rawal et al., 2016). For the logistic regression model, the odds percentage was calculated by subtracting one (1) from the OR and multiplying it by 100. Values were significant if p < 0.05, and CI did not include one. First values (lowest number of the label, 0 or 1) were taken as reference for all the variables except for gender where the reference value was male.
To build a multivariable model for prediction, the following strategy, based on the approach described by Hosmer, Lemeshow, & Sturdivant (2013), was employed. All variables with likelihood ratio test p-values < 0.25 in the bivariate analysis were entered into a single model. Hosmer et al. (2013) advocated the use of higher probabilities such as 0.20 or 0.25 for screening variables because restricting the model to only variables with a traditional probability value of 0.05 or less might miss important variables. Due to their clinical importance, age and sex were included in all multivariable models regardless of statistical significance. The significance of each variable, after controlling for all other variables in the model, was verified by removing variables one at a time, examining changes in the estimated coefficients (compared to the coefficient generated in the bivariate model) and the significance of the Wald chi-square statistic for the remaining variables in the model. If the removal of a variable led to a considerable change in the coefficient value of one or more of the other variables in the model, there was a possible confounding with the variable removed and the variable with the changed coefficient and the outcome. In such a case, the confounding variable would have been maintained in the model. If the potential for effect modification was believed to exist \textit{a priori}, an interaction term between the two variables would be added and examined.

It is possible for the removal of a variable that is not statistically significant in the multivariable model to affect the predictive capability of the model. Such a situation could be detected by examining the difference in log likelihoods between the models with and without the variable by way of a log likelihood test (with degrees of freedom
equal to one less than the number of variables removed from the model). If the log likelihood test was found to be significant, the removed variable was kept in the model.
CHAPTER 5

RESULTS

A total of 1287 NHANES 2013-2014 participants were suitable for inclusion in this study. Each of the estimates and models excluded any missing values (refer to Appendix B for a list of missing values). Means for continuous variables were adjusted for race, gender, and age; for a list of the unadjusted rates, see Appendix D. The statistical significance for most analyses was set at a probability level (p-value) ≤ 0.05. The Standard Error (SE) percentage of mean was the generated by SAS (Barde & Barde, 2012).

Descriptive Statistics

Socio-demographic Characteristics

The socio-demographic characteristics of the study sample are presented in Table 5.1. Half of the sample was female, and the other half was male (49.7% and 50.4% respectively). The age ranged from 60 to 80 years; the range with the most participants was 60-64 years (30.5%). The sample was predominantly Non-Hispanic (NH) white (52.7%). The race with the lowest percentage was ‘Other Hispanic’ which included people of Cuban, Puerto Rican, and other Hispanic backgrounds (7.5%). A little over half of the participants had a level of ‘college or more’ for education (54.5%). The income to poverty ratio was divided into quartiles, with values ranging from one to five. Moreover, the majority of the study subjects were ‘living with someone’ (60.0%). Lastly, a slightly higher percentage of the older adults reported having smoked at least 100 cigarettes at some point in their life (51.9%).
Table 5.1: Summary of socio-demographic characteristics of NHANES participants included in this study

<table>
<thead>
<tr>
<th>Variable</th>
<th>Level</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>639</td>
<td></td>
<td>49.7</td>
</tr>
<tr>
<td>Female</td>
<td>648</td>
<td></td>
<td>50.3</td>
</tr>
<tr>
<td><strong>Age</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>60-64</td>
<td>393</td>
<td></td>
<td>30.5</td>
</tr>
<tr>
<td>65-69</td>
<td>305</td>
<td></td>
<td>23.7</td>
</tr>
<tr>
<td>70-74</td>
<td>249</td>
<td></td>
<td>19.3</td>
</tr>
<tr>
<td>75-80</td>
<td>340</td>
<td></td>
<td>26.5</td>
</tr>
<tr>
<td><strong>Race</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mexican American</td>
<td>133</td>
<td></td>
<td>10.3</td>
</tr>
<tr>
<td>Other Hispanic</td>
<td>96</td>
<td></td>
<td>7.5</td>
</tr>
<tr>
<td>NH White</td>
<td>678</td>
<td></td>
<td>52.7</td>
</tr>
<tr>
<td>NH Black</td>
<td>269</td>
<td></td>
<td>20.9</td>
</tr>
<tr>
<td>Other race</td>
<td>111</td>
<td></td>
<td>8.6</td>
</tr>
<tr>
<td><strong>Education</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High School or less</td>
<td>587</td>
<td></td>
<td>45.6</td>
</tr>
<tr>
<td>College or more</td>
<td>699</td>
<td></td>
<td>54.4</td>
</tr>
<tr>
<td><strong>Income to Poverty Ratio</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;1.2</td>
<td>242</td>
<td></td>
<td>20.4</td>
</tr>
<tr>
<td>1.2-2.1</td>
<td>301</td>
<td></td>
<td>25.3</td>
</tr>
<tr>
<td>2.2-3.9</td>
<td>305</td>
<td></td>
<td>25.7</td>
</tr>
<tr>
<td>&gt;3.9</td>
<td>341</td>
<td></td>
<td>28.7</td>
</tr>
<tr>
<td><strong>Cohabitation Status</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Living with Someone</td>
<td>772</td>
<td></td>
<td>60.0</td>
</tr>
<tr>
<td>Living Alone</td>
<td>514</td>
<td></td>
<td>40.0</td>
</tr>
<tr>
<td><strong>Smoked at least 100 cigarettes in life</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>668</td>
<td></td>
<td>51.9</td>
</tr>
<tr>
<td>No</td>
<td>618</td>
<td></td>
<td>48.1</td>
</tr>
</tbody>
</table>

*a n= Population size
*b %= population size (n) total percentage for the row
*c NH= Non-Hispanic

Health Assessment Variables

**Weight.**

**Current Weight.** As shown in Table 5.2, the mean for the study sample was 80.17 kg, and the values ranged from 36.82 kg to 163.64 kg. Table 5.3 shows the standard error (SE) of the means and the mean kg by age and gender. The mean for
males was higher than for females (89.6 kg vs. 73.8 kg). Similarly, the mean weights tended to decrease as the age increased (Table 5.4).

Table 5.2 Current weight (kg) mean and quartiles

<table>
<thead>
<tr>
<th>Mean</th>
<th>Quartiles</th>
</tr>
</thead>
<tbody>
<tr>
<td>81.3</td>
<td>0% 25% 50% 75% 100%</td>
</tr>
<tr>
<td>36.8</td>
<td>66.8 77.3 90.9 163.6</td>
</tr>
</tbody>
</table>

Table 5.3 Current weight means (kg) and standard errors (SE) by age and gender

<table>
<thead>
<tr>
<th>Gender</th>
<th>Age Cat.</th>
<th>n a</th>
<th>Mean (SE) b</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male (Mean= 89.5 kg)</td>
<td>60-64</td>
<td>194</td>
<td>92.5 (2.24)</td>
</tr>
<tr>
<td></td>
<td>65-69</td>
<td>146</td>
<td>92.8 (2.52)</td>
</tr>
<tr>
<td></td>
<td>70-74</td>
<td>114</td>
<td>87.5 (2.24)</td>
</tr>
<tr>
<td></td>
<td>75-80</td>
<td>182</td>
<td>83.6 (1.59)</td>
</tr>
<tr>
<td>Female (Mean=73.7 kg)</td>
<td>60-64</td>
<td>196</td>
<td>78.8 (2.35)</td>
</tr>
<tr>
<td></td>
<td>65-69</td>
<td>155</td>
<td>71.4 (1.15)</td>
</tr>
<tr>
<td></td>
<td>70-74</td>
<td>132</td>
<td>74.4 (1.14)</td>
</tr>
<tr>
<td></td>
<td>75-80</td>
<td>154</td>
<td>69.1 (1.25)</td>
</tr>
</tbody>
</table>

a n= Population size  
b SE=Standard Error Percentage

Table 5.4 Current weight means and standard errors (SE) by age

<table>
<thead>
<tr>
<th>Age categories</th>
<th>n a</th>
<th>Mean (SE) b</th>
</tr>
</thead>
<tbody>
<tr>
<td>60-64</td>
<td>390</td>
<td>85.5 (1.83)</td>
</tr>
<tr>
<td>65-69</td>
<td>301</td>
<td>81.7 (1.49)</td>
</tr>
<tr>
<td>70-74</td>
<td>246</td>
<td>80.3 (1.08)</td>
</tr>
<tr>
<td>75-80</td>
<td>336</td>
<td>76.1 (1.27)</td>
</tr>
</tbody>
</table>

a n= Population size  
b SE=Standard Error Percentage

Body Mass Index (BMI). The proportion of participants that were obese or overweight was 66.7% while the proportion for underweight was 4.8% (Table 5.5).

Additionally, more females had were underweight, normal and obese (70.4%, 58.9%,
50.7% respectively) while men had the highest percentage (53.6%) for overweight (Table 5.6). Overall, out of all the age ranges, persons aged 60-64 had the highest percentage for underweight, overweight, and obese BMI (37.1%, 30.8%, and 36.8%, respectively). The age range of 75-80 had the highest proportion of normal BMI values (29.7%). These differences were all significant (p>0.05).

Table 5.5 Distribution of Body Mass Index (BMI, kg/m^2)

<table>
<thead>
<tr>
<th>Category</th>
<th>n^a</th>
<th>%^b</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underweight</td>
<td>84</td>
<td>4.8</td>
</tr>
<tr>
<td>Normal</td>
<td>503</td>
<td>28.5</td>
</tr>
<tr>
<td>Overweight</td>
<td>649</td>
<td>36.7</td>
</tr>
<tr>
<td>Obese</td>
<td>531</td>
<td>30.0</td>
</tr>
</tbody>
</table>

^a n= Population size  
^b SE=Standard Error Percentage

Table 5.6 Categories of BMI distribution by gender and age

<table>
<thead>
<tr>
<th>Variable</th>
<th>Underweight</th>
<th>Normal</th>
<th>Overweight</th>
<th>Obese</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>Age Cat.</td>
<td>n^a</td>
<td>%^b</td>
<td>n</td>
</tr>
<tr>
<td>Male</td>
<td>60-64</td>
<td>3</td>
<td>2.5</td>
<td>44</td>
</tr>
<tr>
<td></td>
<td>65-69</td>
<td>4</td>
<td>11.5</td>
<td>39</td>
</tr>
<tr>
<td></td>
<td>70-74</td>
<td>3</td>
<td>8.1</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td>75-80</td>
<td>4</td>
<td>7.4</td>
<td>64</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>14</td>
<td>29.6</td>
<td>175</td>
</tr>
<tr>
<td>Female</td>
<td>60-64</td>
<td>13</td>
<td>34.6</td>
<td>54</td>
</tr>
<tr>
<td></td>
<td>65-69</td>
<td>7</td>
<td>9.3</td>
<td>43</td>
</tr>
<tr>
<td></td>
<td>70-74</td>
<td>6</td>
<td>11.9</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>75-80</td>
<td>6</td>
<td>14.6</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>32</td>
<td>70.4</td>
<td>185</td>
</tr>
<tr>
<td>Total</td>
<td>60-64</td>
<td>16</td>
<td>37.1</td>
<td>98</td>
</tr>
<tr>
<td></td>
<td>65-69</td>
<td>11</td>
<td>20.8</td>
<td>82</td>
</tr>
<tr>
<td></td>
<td>70-74</td>
<td>9</td>
<td>20.0</td>
<td>61</td>
</tr>
<tr>
<td></td>
<td>75-80</td>
<td>10</td>
<td>22.1</td>
<td>119</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>46</td>
<td>100</td>
<td>360</td>
</tr>
</tbody>
</table>

^a n= Population size  
^b % = population size (n) total percentage for the row
**Weight Changes.**

**One-year Weight Change.** The majority of the participants had no weight changes (41.3%). About one-fourth of the participants had an increase in weight for the past year (24.3%), which was the lowest proportion out of all the levels (Table 5.7). These differences across gender and age were significant (p<0.05). Female and male percentages were both close to 50% for all the weight levels (Table 5.8). For the age categories, 60-64 had the highest proportion of participants across all the levels while 70-74 had the lowest (Table 5.7).

Table 5.7 One-year self-reported weight change distribution by gender and age

<table>
<thead>
<tr>
<th>Variable</th>
<th>No change</th>
<th>Decreased</th>
<th>Increased</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>60-64</td>
<td>77</td>
<td>14.0</td>
<td>71</td>
</tr>
<tr>
<td>65-69</td>
<td>68</td>
<td>15.7</td>
<td>47</td>
</tr>
<tr>
<td>70-74</td>
<td>54</td>
<td>10.5</td>
<td>33</td>
</tr>
<tr>
<td>75-80</td>
<td>86</td>
<td>12.3</td>
<td>52</td>
</tr>
<tr>
<td>Total</td>
<td>285</td>
<td>52.4</td>
<td>203</td>
</tr>
<tr>
<td>Female</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>60-64</td>
<td>73</td>
<td>16.7</td>
<td>61</td>
</tr>
<tr>
<td>65-69</td>
<td>51</td>
<td>11.5</td>
<td>51</td>
</tr>
<tr>
<td>70-74</td>
<td>43</td>
<td>8.6</td>
<td>54</td>
</tr>
<tr>
<td>75-80</td>
<td>54</td>
<td>10.8</td>
<td>53</td>
</tr>
<tr>
<td>Total</td>
<td>221</td>
<td>47.6</td>
<td>219</td>
</tr>
<tr>
<td>Both genders</td>
<td>60-64</td>
<td>150</td>
<td>30.7</td>
</tr>
<tr>
<td></td>
<td>65-69</td>
<td>119</td>
<td>27.2</td>
</tr>
<tr>
<td></td>
<td>70-74</td>
<td>97</td>
<td>19.1</td>
</tr>
<tr>
<td></td>
<td>75-80</td>
<td>140</td>
<td>23.0</td>
</tr>
<tr>
<td>Totals</td>
<td>506</td>
<td>41.27</td>
<td>422</td>
</tr>
</tbody>
</table>

\( ^a n = \) Population size  
\( ^b \% = \) population size (n) total percentage for the row

54
Ten-year Weight Change. Weight trends for the past ten years differed from recent weight; 48.3% of the participants had an increase in weight, and only 14.3% reported 'no change' in weight. Another 462 persons (37.4%) said that their weight had declined in the past decade. Female and male percentages were both close to 50% for 'no change' and 'decreased' levels but not for weight 'increased'—where females were 10% higher than males (Table 5.8). Additionally, as shown in Table 5.8, the 75-80 age range had the highest percentage for 'no change' and 'decreased' (26.4% and 30.2% respectively) while 60-64 age range had the highest proportion for weight increase (37.9%). The values across gender and age were statistically significant as well.

Table 5.8 Ten-year self-reported weight change distribution by gender and age

<table>
<thead>
<tr>
<th>Variable</th>
<th>No change</th>
<th>Decreased</th>
<th>Increased</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>n^a</td>
<td>%^b</td>
<td>n</td>
</tr>
<tr>
<td>Male</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>60-64</td>
<td>24</td>
<td>11.9</td>
<td>58</td>
</tr>
<tr>
<td>65-69</td>
<td>27</td>
<td>19.1</td>
<td>45</td>
</tr>
<tr>
<td>70-74</td>
<td>17</td>
<td>7.6</td>
<td>40</td>
</tr>
<tr>
<td>75-80</td>
<td>36</td>
<td>13.4</td>
<td>85</td>
</tr>
<tr>
<td>Total</td>
<td>104</td>
<td>52.0</td>
<td>228</td>
</tr>
<tr>
<td>Female</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>60-64</td>
<td>15</td>
<td>12.7</td>
<td>65</td>
</tr>
<tr>
<td>65-69</td>
<td>13</td>
<td>8.7</td>
<td>60</td>
</tr>
<tr>
<td>70-74</td>
<td>22</td>
<td>13.5</td>
<td>44</td>
</tr>
<tr>
<td>75-80</td>
<td>23</td>
<td>13.1</td>
<td>65</td>
</tr>
<tr>
<td>Total</td>
<td>73</td>
<td>48.0</td>
<td>234</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>60-64</td>
<td>39</td>
<td>24.7</td>
<td>123</td>
</tr>
<tr>
<td>65-69</td>
<td>40</td>
<td>27.8</td>
<td>105</td>
</tr>
<tr>
<td>70-74</td>
<td>39</td>
<td>21.1</td>
<td>84</td>
</tr>
<tr>
<td>75-80</td>
<td>59</td>
<td>26.4</td>
<td>150</td>
</tr>
<tr>
<td>Total</td>
<td>177</td>
<td>100</td>
<td>462</td>
</tr>
</tbody>
</table>

^a^n= Population size
^b%^= population size (n) total percentage for the row
**Handgrip Strength**

*Average Handgrip Strength.* The mean handgrip strength was 30.06 kg of pressure, and the values ranged from 3.2-62.4 kg of pressure (Table 5.9). Males had a higher mean score than did females (Table 5.10). As expected, the mean handgrip strength decreased as the age increased (Table 5.11). Additionally, Table 5.12 shows that ‘NH Black’ had the highest mean (31.0 kg) while ‘Mexican Americans’ had the lowest (28.2 kg).

**Table 5.9** Average handgrip strength (kg) mean and quartiles

<table>
<thead>
<tr>
<th>Mean</th>
<th>Quartiles</th>
</tr>
</thead>
<tbody>
<tr>
<td>30.06</td>
<td>0% 25% 50% 75% 100%</td>
</tr>
<tr>
<td>3.2</td>
<td>22.7  28.6 37.1 62.4</td>
</tr>
</tbody>
</table>

**Table 5.10** Average handgrip strength (kg) frequency and means by gender

<table>
<thead>
<tr>
<th>Gender</th>
<th>n&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Mean (SE)&lt;sup&gt;b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>639</td>
<td>28.0 (2.33)</td>
</tr>
<tr>
<td>Female</td>
<td>648</td>
<td>17.7 (3.16)</td>
</tr>
</tbody>
</table>

<sup>a</sup>n= Population size  
<sup>b</sup>SE=Standard Error Percentage

**Table 5.11** Average handgrip strength (kg) frequency and means by age

<table>
<thead>
<tr>
<th>Age categories</th>
<th>n&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Mean (SE)&lt;sup&gt;b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>60-64</td>
<td>393</td>
<td>33.7 (0.69)</td>
</tr>
<tr>
<td>65-69</td>
<td>305</td>
<td>31.9 (0.74)</td>
</tr>
<tr>
<td>70-74</td>
<td>249</td>
<td>30.1 (0.38)</td>
</tr>
<tr>
<td>75-80</td>
<td>340</td>
<td>26.4 (0.39)</td>
</tr>
</tbody>
</table>

<sup>a</sup>n= Population size  
<sup>b</sup>SE=Standard Error Percentage
Table 5.12 Average handgrip strength (kg) frequency and means by race

<table>
<thead>
<tr>
<th>Race/Hispanic origin</th>
<th>n</th>
<th>Mean (SE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mexican American</td>
<td>133</td>
<td>26.6 (1.50)</td>
</tr>
<tr>
<td>Other Hispanic</td>
<td>96</td>
<td>23.5 (1.34)</td>
</tr>
<tr>
<td>NH White</td>
<td>678</td>
<td>26.5 (0.42)</td>
</tr>
<tr>
<td>NH Black</td>
<td>269</td>
<td>27.3 (2.30)</td>
</tr>
<tr>
<td>Other race</td>
<td>111</td>
<td>23.5 (2.35)</td>
</tr>
</tbody>
</table>

a = Population size  
SE = Standard Error Percentage

Muscle Grip Strength Classification. Participants were classified as normal muscle strength if their handgrip strength was >32 kg for men and >20 kg for women. Otherwise, they were categorized as below normal muscle strength (<32 kg for men and <20 kg for women). Over three-quarters of the study sample had normal muscle grip strength (Table 5.15). Females and participants in the age range of 75-80 years had higher proportions (12.2% and 51.0% respectively) of 'below normal' muscle strength; the percentage of those who had a 'below normal' muscle strength increased as the age increased (Table 5.14). On the other hand, the majority of the participants who had a 'below normal' strength also had a normal or overweight BMI (Table 5.15).
Table 5.13 Muscle grip strength classification distribution by gender

<table>
<thead>
<tr>
<th>Level</th>
<th>Gender</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Below Normal</td>
<td>Male</td>
<td>182</td>
<td>9.9</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>167</td>
<td>12.2</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>349</td>
<td>22.1</td>
</tr>
<tr>
<td>Normal</td>
<td>Male</td>
<td>457</td>
<td>37.7</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>481</td>
<td>40.2</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>938</td>
<td>77.8</td>
</tr>
</tbody>
</table>

\[a n = \text{Population size} \]

\[b \% = \text{population size (n) total percentage for the row} \]

Table 5.14 Muscle grip strength classification distribution by gender and age

<table>
<thead>
<tr>
<th>Variable</th>
<th>Below Normal</th>
<th>Normal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>Age Cat.</td>
<td>n</td>
</tr>
<tr>
<td>Male</td>
<td>60-64</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>65-69</td>
<td>32</td>
</tr>
<tr>
<td></td>
<td>70-74</td>
<td>29</td>
</tr>
<tr>
<td></td>
<td>75-80</td>
<td>91</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>182</td>
</tr>
<tr>
<td>Female</td>
<td>60-64</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>65-69</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>70-74</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td>75-80</td>
<td>79</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>167</td>
</tr>
<tr>
<td>Total</td>
<td>60-64</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>65-69</td>
<td>62</td>
</tr>
<tr>
<td></td>
<td>70-74</td>
<td>57</td>
</tr>
<tr>
<td></td>
<td>75-80</td>
<td>170</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>349</td>
</tr>
</tbody>
</table>

\[a n = \text{Population size} \]

\[b \% = \text{population size (n) total percentage for the row} \]
Table 5.15 Distribution of the categories of BMI by muscle grip strength

<table>
<thead>
<tr>
<th>BMI</th>
<th>Muscle Strength</th>
<th>n&lt;sup&gt;a&lt;/sup&gt;</th>
<th>%&lt;sup&gt;b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underweight</td>
<td>Below Normal</td>
<td>20</td>
<td>1.4</td>
</tr>
<tr>
<td></td>
<td>Normal</td>
<td>26</td>
<td>1.7</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>46</td>
<td>3.1</td>
</tr>
<tr>
<td>Normal</td>
<td>Below Normal</td>
<td>121</td>
<td>7.9</td>
</tr>
<tr>
<td></td>
<td>Normal</td>
<td>239</td>
<td>20.8</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>360</td>
<td>28.7</td>
</tr>
<tr>
<td>Overweight</td>
<td>Below Normal</td>
<td>119</td>
<td>6.7</td>
</tr>
<tr>
<td></td>
<td>Normal</td>
<td>355</td>
<td>29.5</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>474</td>
<td>36.1</td>
</tr>
<tr>
<td>Obese</td>
<td>Below Normal</td>
<td>83</td>
<td>6.0</td>
</tr>
<tr>
<td></td>
<td>Normal</td>
<td>310</td>
<td>26.1</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>393</td>
<td>32.1</td>
</tr>
</tbody>
</table>

<sup>a</sup>n= Population size  
<sup>b</sup>%= population size (n) total percentage for the row

Physical Activity and Functioning

Physically Active. Participants were classified as physically active if they responded ‘yes’ to any of the following variables: vigorous work activity, moderate work activity, participant walked or biked, moderate recreational activity and vigorous recreational activity. Almost 70% of the study sample reported being physically active. Females had the highest proportion of inactivity (Table 5.16). Likewise, those persons aged 75-80 had the highest percentage of inactivity (28.7%) while those aged 60-64 had the highest percentage of activity (34.8%).

Sedentary (Inactive) Hours. The study sample's mean of sedentary hours was 7.15 hours, with a range from 0 to 18 hr. (Table 5.18). Likewise, the means for both sexes were very close to the seven-hour mark (Table 5.17). As shown in Table 5.17, the
mean hours of sedentary activity seemed to increase as the age increased, as the mean for the 75-80 age range was 7.7 hr. for both sexes.

Table 5.16 Physical activity distribution by gender and age

<table>
<thead>
<tr>
<th>Variable</th>
<th>Not Active</th>
<th>Active</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender Age (yr.)</td>
<td>n&lt;sup&gt;a&lt;/sup&gt;</td>
<td>%&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Male</td>
<td></td>
<td></td>
</tr>
<tr>
<td>60-64</td>
<td>46</td>
<td>10.4</td>
</tr>
<tr>
<td>65-69</td>
<td>36</td>
<td>11.8</td>
</tr>
<tr>
<td>70-74</td>
<td>31</td>
<td>7.3</td>
</tr>
<tr>
<td>75-80</td>
<td>64</td>
<td>12.2</td>
</tr>
<tr>
<td>Total</td>
<td>177</td>
<td>41.6</td>
</tr>
<tr>
<td>Female</td>
<td></td>
<td></td>
</tr>
<tr>
<td>60-64</td>
<td>63</td>
<td>15.7</td>
</tr>
<tr>
<td>65-69</td>
<td>49</td>
<td>13.4</td>
</tr>
<tr>
<td>70-74</td>
<td>52</td>
<td>12.8</td>
</tr>
<tr>
<td>75-80</td>
<td>70</td>
<td>16.5</td>
</tr>
<tr>
<td>Total</td>
<td>234</td>
<td>58.4</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
</tr>
<tr>
<td>60-64</td>
<td>109</td>
<td>26.0</td>
</tr>
<tr>
<td>65-69</td>
<td>85</td>
<td>25.2</td>
</tr>
<tr>
<td>70-74</td>
<td>83</td>
<td>20.1</td>
</tr>
<tr>
<td>75-80</td>
<td>134</td>
<td>28.7</td>
</tr>
<tr>
<td>Total</td>
<td>411</td>
<td>100</td>
</tr>
</tbody>
</table>

<sup>a</sup>n= Population size
<sup>b</sup>%= population size (n) total percentage for the row

Table 5.17 Sedentary hours means by age and gender

<table>
<thead>
<tr>
<th>Gender</th>
<th>Age Cat.</th>
<th>Mean (SE)&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male (Mean=8.8)</td>
<td>60-64</td>
<td>7.2 (0.32)</td>
</tr>
<tr>
<td></td>
<td>65-69</td>
<td>6.7 (0.32)</td>
</tr>
<tr>
<td></td>
<td>70-74</td>
<td>7.1 (0.24)</td>
</tr>
<tr>
<td></td>
<td>75-80</td>
<td>7.7 (0.25)</td>
</tr>
<tr>
<td>Female (Mean=7.5)</td>
<td>60-64</td>
<td>7.2 (0.26)</td>
</tr>
<tr>
<td></td>
<td>65-69</td>
<td>6.5 (0.29)</td>
</tr>
<tr>
<td></td>
<td>70-74</td>
<td>6.9 (0.27)</td>
</tr>
<tr>
<td></td>
<td>75-80</td>
<td>7.7 (0.34)</td>
</tr>
</tbody>
</table>

<sup>a</sup>SE=Standard Error Percentage
Instrumental Activities of Daily Living (IADL) Impairment. Results revealed that the over three-quarters of the study sample was not IADL-impaired (Table 5.19). Of those impaired, the majority were female and aged 60-64 (Table 5.19). Overall, a higher proportion of the participants who were IADL impaired were in the 60-64 age range (32.1%).

Table 5.19 Instrumental Activities of Daily Living (IADL) impairment distribution by gender and age

<table>
<thead>
<tr>
<th>Variable</th>
<th>Not Impaired</th>
<th>Impaired</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>nа</td>
<td>%b</td>
</tr>
<tr>
<td>Gender</td>
<td>Age Cat.</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>60-64</td>
<td>141</td>
</tr>
<tr>
<td></td>
<td>65-69</td>
<td>117</td>
</tr>
<tr>
<td></td>
<td>70-74</td>
<td>88</td>
</tr>
<tr>
<td></td>
<td>75-80</td>
<td>133</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>479</td>
</tr>
<tr>
<td>Female</td>
<td>60-64</td>
<td>144</td>
</tr>
<tr>
<td></td>
<td>65-69</td>
<td>113</td>
</tr>
<tr>
<td></td>
<td>70-74</td>
<td>103</td>
</tr>
<tr>
<td></td>
<td>75-80</td>
<td>102</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>462</td>
</tr>
<tr>
<td>Total</td>
<td>60-64</td>
<td>285</td>
</tr>
<tr>
<td></td>
<td>65-69</td>
<td>230</td>
</tr>
<tr>
<td></td>
<td>70-74</td>
<td>191</td>
</tr>
<tr>
<td></td>
<td>75-80</td>
<td>235</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>941</td>
</tr>
</tbody>
</table>

аn = Population size
b% = population size (n) total percentage for the row
Self-Rated Health Assessment. Table 5.20 shows that the majority of the study sample rated their health as ‘Excellent,’ ‘Very Good’ (VG), or ‘Good.’ Women aged 60-64 had the highest percentage of self-reported ‘poor health’ (Table 5.21).

Table 5.20 Self-rated health condition distribution

<table>
<thead>
<tr>
<th>Level</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent/Very Good/Good</td>
<td>962</td>
<td>74.8</td>
</tr>
<tr>
<td>Fair</td>
<td>264</td>
<td>20.5</td>
</tr>
<tr>
<td>Poor</td>
<td>61</td>
<td>4.7</td>
</tr>
</tbody>
</table>

\[n^a = \text{Population size}\]

\[%^b = \text{population size (n) total percentage for the row}\]

Table 5.21 Self-rated health assessment distribution by gender and age

<table>
<thead>
<tr>
<th>Variable</th>
<th>Excellent/VG/Good(^a)</th>
<th>Fair</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>Age Cat.</td>
<td>n(^b)</td>
<td>%(^c)</td>
</tr>
<tr>
<td>Male</td>
<td>60-64</td>
<td>139</td>
<td>15.3</td>
</tr>
<tr>
<td></td>
<td>65-69</td>
<td>111</td>
<td>12.3</td>
</tr>
<tr>
<td></td>
<td>70-74</td>
<td>81</td>
<td>7.6</td>
</tr>
<tr>
<td></td>
<td>75-80</td>
<td>142</td>
<td>11.8</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>473</td>
<td>47.0</td>
</tr>
<tr>
<td>Female</td>
<td>60-64</td>
<td>147</td>
<td>17.2</td>
</tr>
<tr>
<td></td>
<td>65-69</td>
<td>122</td>
<td>14.1</td>
</tr>
<tr>
<td></td>
<td>70-74</td>
<td>100</td>
<td>10.1</td>
</tr>
<tr>
<td></td>
<td>75-80</td>
<td>120</td>
<td>11.7</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>489</td>
<td>53.0</td>
</tr>
<tr>
<td>Total</td>
<td>60-64</td>
<td>286</td>
<td>32.5</td>
</tr>
<tr>
<td></td>
<td>65-69</td>
<td>233</td>
<td>26.4</td>
</tr>
<tr>
<td></td>
<td>70-74</td>
<td>181</td>
<td>17.7</td>
</tr>
<tr>
<td></td>
<td>75-80</td>
<td>262</td>
<td>23.4</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>962</td>
<td>100</td>
</tr>
</tbody>
</table>

\[n^b = \text{Population size}\]

\[%^c = \text{population size (n) total percentage for the row}\]
**Poor Appetite or Overeating.** Almost 80% of the study population had no presence of poor appetite or overeating (Table 5.22). Table 5.23 shows that the majority of those who denied any change in appetite were females (64.6%) and were in the range of 60-64 (29.3%); those aged 70-74 had the lowest percentage (16.6%). Interestingly, the age range of 60-64 also had the highest proportion for those who reported appetite changes.

Table 5.22 Self-reported poor appetite or overeating

<table>
<thead>
<tr>
<th>Level</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>983</td>
<td>78.2</td>
</tr>
<tr>
<td>Yes</td>
<td>274</td>
<td>21.8</td>
</tr>
</tbody>
</table>

*a* n= Population size  
*b* % = population size (n) total percentage for the row

Table 5.23 Distribution of poor appetite or overeating by gender and age

<table>
<thead>
<tr>
<th>Variable</th>
<th>No</th>
<th>Yes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gender</strong></td>
<td><strong>Age Cat.</strong></td>
<td><strong>n</strong></td>
</tr>
<tr>
<td><strong>Male</strong></td>
<td>60-64</td>
<td>147</td>
</tr>
<tr>
<td>65-69</td>
<td>124</td>
<td>14.3</td>
</tr>
<tr>
<td>70-74</td>
<td>92</td>
<td>8.2</td>
</tr>
<tr>
<td>75-80</td>
<td>157</td>
<td>13.0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>520</td>
</tr>
<tr>
<td><strong>Female</strong></td>
<td>60-64</td>
<td>130</td>
</tr>
<tr>
<td>65-69</td>
<td>108</td>
<td>12.4</td>
</tr>
<tr>
<td>70-74</td>
<td>111</td>
<td>11.2</td>
</tr>
<tr>
<td>75-80</td>
<td>114</td>
<td>11.6</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>463</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>60-64</td>
<td>277</td>
</tr>
<tr>
<td>65-69</td>
<td>232</td>
<td>26.7</td>
</tr>
<tr>
<td>70-74</td>
<td>203</td>
<td>19.4</td>
</tr>
<tr>
<td>75-80</td>
<td>271</td>
<td>24.6</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>983</td>
</tr>
</tbody>
</table>

*a* n= Population size  
*b* % = population size (n) total percentage for the row
Smell Disorder Assessment Variables

Smell Examination Component

Individual Scents. The majority of persons in the study sample were able to identify the scents correctly (Table 5.24). However, the smell that was identified incorrectly the most often was grape (39.0%). Out of the eight scents in Table 5.24, three were selected for further analysis: grape, smoke, and gas. Gas and smoke were chosen because of the health and safety concern related to them, while grape was selected because of its high prevalence of ‘wrong’ answers. For grape scent, the age range with the highest percentage of ‘wrong’ was 75-80 (29.1%). Similarly, for smoke and gas, the 75-80 age range had the highest proportion for incorrect answers (48.4% and 37.8% respectively). Table 5.26 shows that the majority of those who failed to identify the smoke and gas scent were males (60.1% and 59.6% respectively).

Scent Test Total Scores. As seen in Table 5.27, the majority of the study population had a score above five (89.9%). The highest score test was eight, while the lowest was zero (29.76% and 0.23%, respectively).

Table 5.24 Distribution of the individual scents from the smell test

<table>
<thead>
<tr>
<th>Scent</th>
<th>n^a</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Right</td>
</tr>
<tr>
<td>Chocolate</td>
<td>1067</td>
</tr>
<tr>
<td>Strawberry</td>
<td>1008</td>
</tr>
<tr>
<td>Smoke</td>
<td>1094</td>
</tr>
<tr>
<td>Leather</td>
<td>950</td>
</tr>
<tr>
<td>Soap</td>
<td>1174</td>
</tr>
<tr>
<td>Grape</td>
<td>785</td>
</tr>
<tr>
<td>Onion</td>
<td>1189</td>
</tr>
<tr>
<td>Gas</td>
<td>1065</td>
</tr>
</tbody>
</table>

^a n= Population size
Table 5.25 Gender and age distribution of persons who failed to identify the grape scent correctly

<table>
<thead>
<tr>
<th>Variables</th>
<th>Grape-‘Wrong’</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>Age Cat.</td>
</tr>
<tr>
<td>Male</td>
<td>60-64</td>
</tr>
<tr>
<td></td>
<td>65-69</td>
</tr>
<tr>
<td></td>
<td>70-74</td>
</tr>
<tr>
<td></td>
<td>75-80</td>
</tr>
<tr>
<td></td>
<td>Total</td>
</tr>
<tr>
<td>Female</td>
<td>60-64</td>
</tr>
<tr>
<td></td>
<td>65-69</td>
</tr>
<tr>
<td></td>
<td>70-74</td>
</tr>
<tr>
<td></td>
<td>75-80</td>
</tr>
<tr>
<td></td>
<td>Total</td>
</tr>
<tr>
<td>Total</td>
<td>60-64</td>
</tr>
<tr>
<td></td>
<td>65-69</td>
</tr>
<tr>
<td></td>
<td>70-74</td>
</tr>
<tr>
<td></td>
<td>75-80</td>
</tr>
<tr>
<td></td>
<td>Total</td>
</tr>
</tbody>
</table>

^a n = Population size  ^b % = population size (n) total percentage for the row

Table 5.26 Gender and age distribution of persons who failed to identify the smoke and gas scent correctly

<table>
<thead>
<tr>
<th>Variables</th>
<th>Smoke-‘Wrong’</th>
<th>Gas-‘Wrong’</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>Age Cat.</td>
<td>n^a</td>
</tr>
<tr>
<td>Male</td>
<td>60-64</td>
<td>27</td>
</tr>
<tr>
<td></td>
<td>65-69</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>70-74</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>75-80</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>122</td>
</tr>
<tr>
<td>Female</td>
<td>60-64</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>65-69</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>70-74</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>75-80</td>
<td>27</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>71</td>
</tr>
<tr>
<td>Total</td>
<td>60-64</td>
<td>42</td>
</tr>
<tr>
<td></td>
<td>65-69</td>
<td>29</td>
</tr>
<tr>
<td></td>
<td>70-74</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>75-80</td>
<td>82</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>193</td>
</tr>
</tbody>
</table>

^a n = Population size  ^b % = population size (n) total percentage for the row
Table 5.27 Distribution of the total scent test scores

<table>
<thead>
<tr>
<th>Total score</th>
<th>n&lt;sup&gt;a&lt;/sup&gt;</th>
<th>%&lt;sup&gt;b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>3</td>
<td>0.23</td>
</tr>
<tr>
<td>1</td>
<td>7</td>
<td>0.54</td>
</tr>
<tr>
<td>2</td>
<td>22</td>
<td>1.71</td>
</tr>
<tr>
<td>3</td>
<td>25</td>
<td>1.94</td>
</tr>
<tr>
<td>4</td>
<td>73</td>
<td>5.67</td>
</tr>
<tr>
<td>5</td>
<td>149</td>
<td>11.58</td>
</tr>
<tr>
<td>6</td>
<td>256</td>
<td>19.89</td>
</tr>
<tr>
<td>7</td>
<td>383</td>
<td>29.76</td>
</tr>
<tr>
<td>8</td>
<td>369</td>
<td>28.67</td>
</tr>
</tbody>
</table>

<sup>a</sup>n= Population size  
<sup>b</sup>%= population size (n) total percentage for the row

Presence of Smell Impairment. The presence of a smell impairment was calculated from the total smell score, which in turn was calculated from the number of scents that were identified correctly. If the scent test total was greater or equal than five, the individual did not have a smell impairment; those with scores less than five had a smell impairment present. Table 5.28 shows that less than one-quarter of the study sample had a smell impairment (21.7%). Of those who had a smell impairment, the highest proportion (7.7%) was found in the 75-80 years age range (Table 5.29). A higher number of males had a smell impairment when compared to females (Table 5.30).

Table 5.28 Distribution of the smell impairment

<table>
<thead>
<tr>
<th>Level</th>
<th>n&lt;sup&gt;a&lt;/sup&gt;</th>
<th>%&lt;sup&gt;b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Smell Impairment (total scent identification score ≥ 5)</td>
<td>1008</td>
<td>78.3</td>
</tr>
<tr>
<td>Smell impairment present (total scent identification score &lt;5)</td>
<td>279</td>
<td>21.7</td>
</tr>
</tbody>
</table>

<sup>a</sup>n= Population size  
<sup>b</sup>%= population size (n) total percentage for the row
Table 5.29 Distribution of smell impairment by age

<table>
<thead>
<tr>
<th>Age Cat.</th>
<th>No SI(^b)</th>
<th>SI Present</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n(^b)</td>
<td>%(^c)</td>
</tr>
<tr>
<td>60-64</td>
<td>334</td>
<td>27.9</td>
</tr>
<tr>
<td>65-69</td>
<td>259</td>
<td>22.7</td>
</tr>
<tr>
<td>70-74</td>
<td>200</td>
<td>15.8</td>
</tr>
<tr>
<td>75-80</td>
<td>215</td>
<td>16.0</td>
</tr>
</tbody>
</table>

\(^a\)SI= Smell Impairment  
\(^b\)n= Population size  
\(^c\)%= population size (n) total percentage for the row

Table 5.30 Distribution of smell impairment by gender

<table>
<thead>
<tr>
<th>Gender</th>
<th>No SI(^b)</th>
<th>SI Present</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n(^b)</td>
<td>%(^c)</td>
</tr>
<tr>
<td>Male</td>
<td>471</td>
<td>37.3</td>
</tr>
<tr>
<td>Female</td>
<td>537</td>
<td>45.1</td>
</tr>
</tbody>
</table>

\(^a\)SI= Smell Impairment  
\(^b\)n= Population size  
\(^c\)%= population size (n) total percentage for the row

Table 5.31 Presence of smell impairment (‘SI Present’) distribution by gender and age

<table>
<thead>
<tr>
<th>Variable</th>
<th>No SI(^b)</th>
<th>SI Present</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age Cat.</td>
<td>Male</td>
<td>Female</td>
</tr>
<tr>
<td></td>
<td>n(^b)</td>
<td>%(^c)</td>
</tr>
<tr>
<td>60-64</td>
<td>31</td>
<td>13.8</td>
</tr>
<tr>
<td>65-69</td>
<td>26</td>
<td>8.8</td>
</tr>
<tr>
<td>70-74</td>
<td>28</td>
<td>8.9</td>
</tr>
<tr>
<td>75-80</td>
<td>83</td>
<td>26.7</td>
</tr>
</tbody>
</table>

\(^a\)SI= Smell Impairment  
\(^b\)n= Population size  
\(^c\)%= population size (n) total percentage for the row

Smell Questionnaire Component

Smell Questionnaire Variables. Table 5.32 summarizes the smell alteration questionnaire variables. More than 90% of the participants responded 'No' to the three
odor questions. Also, from Table 5.32, CSQ010 (problem with smell) was the question with the most affirmative responses (8.5%). Men had the highest percentages on affirmative responses for CSQ010 and CSQ_change (changes in the ability to smell), while more women reported the presence of a phantom odor (Table 5.33).

As shown in Table 5.34, the majority of the participants reported 'No' for the confounders of smell. Additionally, CSQ 204, persistent cold/flu over the last 12 months had the most affirmative responses with 6.9% (Table 5.34).

**Smell Alteration Total Score.** As mentioned previously, the variables used for smell alteration total score were from the smell questionnaire: CSQ010, CSQ040, and CSQ_change. The range of the scores was zero to two, meaning that no participants answered affirmative to all of the three questions (Table 5.35).

**Self-Reported Smell Alteration.** Those who had a smell alteration score equal to or greater than one were classified as having a smell alteration ('SA Present'); otherwise, they did not have a smell alteration ('No SA'). Table 5.36 shows that the majority of the study sample did not have a smell alteration (83.8%). Results by age (Table 5.37) showed that a higher percentage of those who reported a smell alteration ('SA Present') were in the age range of 60-64 – unlike those with a smell impairment who were in the range 70-75. Similar to smell impairment, males also had a higher proportion than females for the presence of self-reported smell alteration, 9.0% for men versus 8.5% which was not significantly different for women (Table 5.38). Table 5.39 shows that across all levels, female aged 60-64 had the most responses for the alteration (20.9%).
Table 5.32: Distributions of the smell alteration questionnaire variables responses

<table>
<thead>
<tr>
<th>Had a problem with smell past 12 months? (CSQ010)</th>
<th>Level</th>
<th>n&lt;sup&gt;a&lt;/sup&gt;</th>
<th>%&lt;sup&gt;b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>1178</td>
<td>91.5</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>109</td>
<td>8.5</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Had phantom odor? (CSQ040)</th>
<th>Level</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>1227</td>
<td>95.3</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>60</td>
<td>4.7</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ability to smell since age 25 (CSQ_change)</th>
<th>Level</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not Changed/Better</td>
<td>1223</td>
<td>95.3</td>
<td></td>
</tr>
<tr>
<td>Changed</td>
<td>60</td>
<td>4.7</td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup>n= Population size  
<sup>b</sup>%= population size (n) total percentage for the row

Table 5.33 Affirmative responses for smell alteration questionnaire variables by gender and age

<table>
<thead>
<tr>
<th>Variables</th>
<th>CSQ010</th>
<th>CSQ040</th>
<th>CSQ_change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender Age Cat.</td>
<td>n&lt;sup&gt;a&lt;/sup&gt;</td>
<td>%&lt;sup&gt;b&lt;/sup&gt;</td>
<td>n</td>
</tr>
<tr>
<td>Male</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>60-64</td>
<td>12</td>
<td>14.9</td>
<td>10</td>
</tr>
<tr>
<td>65-69</td>
<td>8</td>
<td>8.7</td>
<td>12</td>
</tr>
<tr>
<td>70-74</td>
<td>13</td>
<td>14.8</td>
<td>4</td>
</tr>
<tr>
<td>75-80</td>
<td>21</td>
<td>15.7</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>54</td>
<td>54.2</td>
<td>27</td>
</tr>
<tr>
<td>Female</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>60-64</td>
<td>16</td>
<td>17.0</td>
<td>16</td>
</tr>
<tr>
<td>65-69</td>
<td>11</td>
<td>5.9</td>
<td>6</td>
</tr>
<tr>
<td>70-74</td>
<td>10</td>
<td>10.0</td>
<td>9</td>
</tr>
<tr>
<td>75-80</td>
<td>18</td>
<td>12.9</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>55</td>
<td>45.8</td>
<td>33</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Variables</th>
<th>CSQ010</th>
<th>CSQ040</th>
<th>CSQ_change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender Age Cat.</td>
<td>n&lt;sup&gt;a&lt;/sup&gt;</td>
<td>%&lt;sup&gt;b&lt;/sup&gt;</td>
<td>n</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>60-64</td>
<td>28</td>
<td>31.9</td>
<td>26</td>
</tr>
<tr>
<td>65-69</td>
<td>19</td>
<td>14.6</td>
<td>18</td>
</tr>
<tr>
<td>70-74</td>
<td>23</td>
<td>24.9</td>
<td>13</td>
</tr>
<tr>
<td>75-80</td>
<td>39</td>
<td>28.6</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>109</td>
<td>100</td>
<td>60</td>
</tr>
</tbody>
</table>

<sup>a</sup>n= Population size  
<sup>b</sup>%= population size (n) total percentage for the row

69
Table 5.34 Distributions of smell confounding questionnaire variables responses

<table>
<thead>
<tr>
<th>Persistent cold/flu last 12 months?</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>CSQ200</td>
<td>n</td>
<td>%</td>
</tr>
<tr>
<td>No</td>
<td>1197</td>
<td>93.0</td>
</tr>
<tr>
<td>Yes</td>
<td>90</td>
<td>7.0</td>
</tr>
</tbody>
</table>

| Frequent nasal congestion in past 12 months? |           |       |
| CSQ204                                       | n         | %     |
| No                                            | 889       | 69.3  |
| Yes                                           | 393       | 30.7  |

| Head Injury/Loss of consciousness         |           |       |
| CSQ240                                      | n         | %     |
| No                                          | 1107      | 86.2  |
| Yes                                         | 177       | 13.8  |

| Broke Nose/Serious Injury to Face/Skull    |           |       |
| CSQ250                                      | n         | %     |
| No                                          | 1108      | 86.3  |
| Yes                                         | 176       | 13.7  |

\[^a\text{n}= \text{Population size}\]
\[^b\text{%}= \text{population size (n) total percentage for the row}\]

Table 5.35 Distribution of smell alteration total scores

<table>
<thead>
<tr>
<th>Score</th>
<th>n[^a]</th>
<th>%[^b]</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1074</td>
<td>83.6</td>
</tr>
<tr>
<td>1</td>
<td>189</td>
<td>14.7</td>
</tr>
<tr>
<td>2</td>
<td>20</td>
<td>1.6</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

\[^a\text{n}= \text{Population size}\]
\[^b\text{%}= \text{population size (n) total percentage for the row}\]
Table 5.36 Distribution of self-reported smell alteration

<table>
<thead>
<tr>
<th>Level</th>
<th>n^a</th>
<th>%^b</th>
</tr>
</thead>
<tbody>
<tr>
<td>No SA^c</td>
<td>1078</td>
<td>83.8</td>
</tr>
<tr>
<td>SA Present</td>
<td>209</td>
<td>16.2</td>
</tr>
</tbody>
</table>

^a n = Population size
^b % = population size (n) total percentage for the row
^c SA = Smell Alteration

Table 5.37 Distribution of self-reported smell alteration by age

<table>
<thead>
<tr>
<th>Age Cat.</th>
<th>No SA^a</th>
<th>SA Present</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n^b</td>
<td>%^c</td>
</tr>
<tr>
<td>60-64</td>
<td>326</td>
<td>25.3</td>
</tr>
<tr>
<td>65-69</td>
<td>259</td>
<td>21.6</td>
</tr>
<tr>
<td>70-74</td>
<td>207</td>
<td>15.2</td>
</tr>
<tr>
<td>75-80</td>
<td>286</td>
<td>20.4</td>
</tr>
</tbody>
</table>

^a SA = Smell Alteration
^b n = Population size
^c % = population size (n) total percentage for the row

Table 5.38 Distribution of self-reported smell alteration by gender

<table>
<thead>
<tr>
<th>Gender</th>
<th>No SA^a</th>
<th>SA Present</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n^b</td>
<td>%^c</td>
</tr>
<tr>
<td>Male</td>
<td>531</td>
<td>38.6</td>
</tr>
<tr>
<td>Female</td>
<td>547</td>
<td>43.9</td>
</tr>
</tbody>
</table>

^a SA = Smell Alteration
^b n = Population size
^c % = population size (n) total percentage for the row
Table 5.39 Distribution of the presence of a self-reported smell alteration (‘SA Present’) by gender and age

<table>
<thead>
<tr>
<th>Variable</th>
<th>SA³ Present</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
</tr>
<tr>
<td></td>
<td>n⁵</td>
</tr>
<tr>
<td>Age Cat.</td>
<td></td>
</tr>
<tr>
<td>60-64</td>
<td>30</td>
</tr>
<tr>
<td>65-69</td>
<td>25</td>
</tr>
<tr>
<td>70-74</td>
<td>21</td>
</tr>
<tr>
<td>75-80</td>
<td>32</td>
</tr>
<tr>
<td>Total</td>
<td>108</td>
</tr>
</tbody>
</table>

³SA= Smell Alteration
⁵n= Population size
⁷%= population size (n) total percentage for the row

Smell Dysfunction. An individual was classified as having a smell dysfunction (‘Yes’) if they had a presence of a smell impairment and or self-reported smell alteration. Results from Tables 5.40-5.42 show that 32.1% of the sample had a smell dysfunction of which the majority was male and in the 75-80 age range (statistically significant).

Table 5.40 Distribution of the presence of a smell dysfunction

<table>
<thead>
<tr>
<th>Level</th>
<th>n⁵</th>
<th>%⁷</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>874</td>
<td>67.9</td>
</tr>
<tr>
<td>Yes</td>
<td>413</td>
<td>32.1</td>
</tr>
</tbody>
</table>

⁵n= Population size
⁷%= population size (n) total percentage for the row
Table 5.41 Distribution of smell dysfunction by gender

<table>
<thead>
<tr>
<th>Gender</th>
<th>No</th>
<th></th>
<th>Yes</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n(^a)</td>
<td>%(^b)</td>
<td>n</td>
<td>%</td>
</tr>
<tr>
<td>Male</td>
<td>407</td>
<td>31.6 (1.27)</td>
<td>232</td>
<td>16.0 (0.99)</td>
</tr>
<tr>
<td>Female</td>
<td>467</td>
<td>38.6 (1.36)</td>
<td>181</td>
<td>13.8 (1.31)</td>
</tr>
</tbody>
</table>

\(^a\) n = Population size  
\(^b\) % = population size (n) total percentage for the row

Table 5.42 Distribution of smell dysfunction by age

<table>
<thead>
<tr>
<th>Age Cat.</th>
<th>No</th>
<th></th>
<th>Yes</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n(^a)</td>
<td>%(^b)</td>
<td>n</td>
<td>%</td>
</tr>
<tr>
<td>60-64</td>
<td>283</td>
<td>22.7 (1.66)</td>
<td>110</td>
<td>9.3 (1.29)</td>
</tr>
<tr>
<td>65-69</td>
<td>224</td>
<td>19.3 (1.63)</td>
<td>81</td>
<td>6.3 (0.67)</td>
</tr>
<tr>
<td>70-74</td>
<td>173</td>
<td>13.5 (1.79)</td>
<td>76</td>
<td>5.2 (0.85)</td>
</tr>
<tr>
<td>75-80</td>
<td>194</td>
<td>14.7 (1.31)</td>
<td>146</td>
<td>9.0 (1.01)</td>
</tr>
</tbody>
</table>

\(^a\) n = Population size  
\(^b\) % = population size (n) total percentage for the row

**Prevalence Rates**

The estimated total U.S population for adults over 60 years of age at the time of our study sample was 44,500,000; of those, the estimated prevalence of smell impairment was 6,844,000 people or 15.4% (Table 5.43). Table 5.44 shows that the population estimate was higher for males across all the variables. For smell alteration, its population estimate was 7,787,500 or 17.5%. The prevalence of smell impairment and or smell alteration (smell dysfunction) was 29.8% (Table 5.43). Lastly, the highest estimated percentage of the U.S population with smell alteration was 'Mexican Americans' (Mex-Am) while for smell impairment, it was ‘Other Race’ (Figure 5.1).
Table 5.43 Percent and population estimates of adults over 60 years of age with smell disorders in the U.S

<table>
<thead>
<tr>
<th>Level</th>
<th>%c</th>
<th>US Pop. Est.</th>
<th>Total U.S Pop. Est.</th>
</tr>
</thead>
<tbody>
<tr>
<td>SI(^a) Present</td>
<td>15.4</td>
<td>6,844,000</td>
<td>44,500,000</td>
</tr>
<tr>
<td>SA(^b) Present</td>
<td>17.5</td>
<td>7,787,500</td>
<td></td>
</tr>
<tr>
<td>Smell Dysfunction</td>
<td>29.8</td>
<td>13,261,000</td>
<td></td>
</tr>
</tbody>
</table>

\(^a\)SI= Smell Alteration  
\(^b\)SA= Smell Alteration  
\(^c\)%= percentage of the estimated population with a smell disorder  
\(^d\)Pop. Est.= Population Estimate for adults over 60 years of age

Table 5.44 Percentage estimates of adults over 60 years of age with smell disorders in the U.S by gender

<table>
<thead>
<tr>
<th>Gender</th>
<th>SI(^a) Present (%)</th>
<th>SA(^b) Present (%)</th>
<th>Smell Dysf. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>16.51</td>
<td>18.9</td>
<td>33.6</td>
</tr>
<tr>
<td>Female</td>
<td>14.36</td>
<td>16.3</td>
<td>26.3</td>
</tr>
</tbody>
</table>

\(^a\)SI= Smell Alteration  
\(^b\)SA= Smell Alteration  
\(^c\)%= percentage of the estimated population with a smell disorder

Figure 5.1 Percent estimates of smell disorders for the U.S population by race

Race Categories

SI= Smell Impairment; SA= Smell Alteration
Hypothesis Testing Statistics

Smell Disorder Assessment Variables

Smell Impairment. Among the socio-demographic characteristics, the distributions for gender, age, race, and education differed significantly \( p < 0.05 \). In general, for race, ‘Non-Hispanic (NH) White’ had the highest proportion (47.6%) of smell impairment (‘SI Present’). The percentage of those smell impaired was also higher among persons with an education level of ‘high school or less’ (55.2% vs. 44.8%). Although there were not statistically significant differences between cohabitation status and smell impairment, there was a higher number (%) of people ‘living with someone’ who had the presence of a smell impairment (59.5%) than those who lived alone (40.5%).

Overall, the health assessment variables that were statistically significant \( p < 0.05 \) with smell impairment were self-rated health, IADL impairment, muscle strength classification, and sedentary hours (Table 5.46). Similarly, those IADL impaired and with ‘excellent’/’VG’/’Good’ (will be referred to as ‘normal’) self-rated health had high rates of smell impairment (Table 5.46). Table 5.47 also shows that smell impairment was statistically significant with smell alteration. Almost three-quarters of the study sample, self-reported no smell alteration but had a smell impairment present (failed the scent smell test). None of the confounding smell variables (CSQ 200, CSQ 204, CSQ 240 and CSQ 250) were significantly associated \( p > 0.05 \); the majority of the people who had smell impairment or self-reported alteration (>75%) responded ‘No’ to those questions. The mean for handgrip strength and current weight were not significantly lower in those with a smell impairment (Table 5.48). On the contrary, the hours of
sedentary activity were higher in those with a smell impairment present (p=0.006, Table 5.48).

**Smell Alteration.** Table 5.45 shows that smell alteration was statistically significant (p<0.05) with age; there was a proportion of person in the 60-64 category (38.5%). From the health assessment characteristics, IADL impairment, current weight, and BMI were the only variables with significant values (p<0.05). The majority (69.4%) of those who had a smell alteration did not have a smell impairment; only 30.6% of participants had a smell alteration and smell impairment present (Table 5.47). Smell alteration was not statistically significant with handgrip strength or sedentary hours (p>0.05, Table 5.48). Table 5.49 shows that persons with a self-reported smell alteration had a higher BMI (overweight and obese). The mean of current weight for ‘SA Present’ was higher (86.3 kg) than for those with no smell alteration (Table 5.49).
Table 5.45 Prevalence of the presence of smell impairment and smell alteration by sociodemographic characteristics in participants 60+ years (N=1285)

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>‘SI’ Present’</th>
<th></th>
<th></th>
<th>‘SA’ Present’</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n&lt;sup&gt;c&lt;/sup&gt;</td>
<td>%&lt;sup&gt;d&lt;/sup&gt;</td>
<td>P-value</td>
<td>n</td>
<td>%</td>
<td>P-value</td>
</tr>
<tr>
<td>Totals</td>
<td>279</td>
<td>21.68</td>
<td>n/a</td>
<td>209</td>
<td>16.24</td>
<td>n/a</td>
</tr>
<tr>
<td><strong>Socio-demographic</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Age Categories</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;60-64</td>
<td>59</td>
<td>21.1</td>
<td>&lt;0.001</td>
<td>67</td>
<td>38.5</td>
<td></td>
</tr>
<tr>
<td>65-69</td>
<td>46</td>
<td>16.5</td>
<td></td>
<td>46</td>
<td>22.7</td>
<td>0.023</td>
</tr>
<tr>
<td>70-74</td>
<td>49</td>
<td>17.5</td>
<td></td>
<td>42</td>
<td>19.8</td>
<td></td>
</tr>
<tr>
<td>75-80</td>
<td>125</td>
<td>44.8</td>
<td></td>
<td>54</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>168</td>
<td>60.2</td>
<td>0.045</td>
<td>108</td>
<td>51.3</td>
<td>0.271</td>
</tr>
<tr>
<td>Female</td>
<td>111</td>
<td>39.8</td>
<td></td>
<td>101</td>
<td>48.7</td>
<td></td>
</tr>
<tr>
<td><strong>Race</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mexican American</td>
<td>22</td>
<td>7.9</td>
<td></td>
<td>25</td>
<td>4.3</td>
<td></td>
</tr>
<tr>
<td>Other Hispanic</td>
<td>26</td>
<td>9.3</td>
<td>0.019</td>
<td>11</td>
<td>2.1</td>
<td>0.895</td>
</tr>
<tr>
<td>Non-Hispanic White</td>
<td>133</td>
<td>47.6</td>
<td></td>
<td>119</td>
<td>81.8</td>
<td></td>
</tr>
<tr>
<td>Non-Hispanic Black</td>
<td>67</td>
<td>24</td>
<td></td>
<td>42</td>
<td>7.9</td>
<td></td>
</tr>
<tr>
<td>Other race</td>
<td>31</td>
<td>11.1</td>
<td></td>
<td>12</td>
<td>3.9</td>
<td></td>
</tr>
<tr>
<td><strong>Education Level</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High School or less</td>
<td>154</td>
<td>55.2</td>
<td>0.0003</td>
<td>95</td>
<td>36.9</td>
<td>0.666</td>
</tr>
<tr>
<td>College or more</td>
<td>125</td>
<td>44.8</td>
<td></td>
<td>114</td>
<td>63.1</td>
<td></td>
</tr>
<tr>
<td><strong>Income</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;1.2</td>
<td>47</td>
<td>16.8</td>
<td></td>
<td>40</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>1.2-2.1</td>
<td>80</td>
<td>28.8</td>
<td>0.086</td>
<td>59</td>
<td>25.1</td>
<td>0.343</td>
</tr>
<tr>
<td>2.2-3.9</td>
<td>66</td>
<td>23.6</td>
<td></td>
<td>47</td>
<td>28.8</td>
<td></td>
</tr>
<tr>
<td>&gt;3.9</td>
<td>64</td>
<td>22.9</td>
<td></td>
<td>54</td>
<td>36.1</td>
<td></td>
</tr>
<tr>
<td><strong>Cohabitation Status</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Living with Someone</td>
<td>166</td>
<td>59.5</td>
<td>0.054</td>
<td>130</td>
<td>67.6</td>
<td>0.204</td>
</tr>
<tr>
<td>Living Alone</td>
<td>113</td>
<td>40.5</td>
<td></td>
<td>79</td>
<td>32.5</td>
<td></td>
</tr>
<tr>
<td><strong>Smoked at least 100 cigarettes in life?</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>129</td>
<td>46.2</td>
<td>0.604</td>
<td>83</td>
<td>41.6</td>
<td>0.115</td>
</tr>
<tr>
<td>Yes</td>
<td>149</td>
<td>53.4</td>
<td></td>
<td>126</td>
<td>58.3</td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup>SI= Smell Impairment  
<sup>b</sup>SA= Smell Alteration  
<sup>c</sup>n= Population size  
<sup>d</sup>%= population size (n) total percentage for the row
Table 5.46 Prevalence of the presence smell impairment and smell alteration by health characteristics in participants 60+ years (N=1285)

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>‘SI’ Present</th>
<th></th>
<th>‘SA Present’</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>%</td>
<td>P-value</td>
<td>n</td>
</tr>
<tr>
<td>Muscle Strength Cat.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Below Normal</td>
<td>115</td>
<td>41.2</td>
<td>0.0023</td>
<td>58</td>
</tr>
<tr>
<td>Normal</td>
<td>164</td>
<td>58.8</td>
<td></td>
<td>151</td>
</tr>
<tr>
<td>BMI</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Underweight</td>
<td>11</td>
<td>3.9</td>
<td>0.2345</td>
<td>10</td>
</tr>
<tr>
<td>Normal</td>
<td>96</td>
<td>34.4</td>
<td></td>
<td>43</td>
</tr>
<tr>
<td>Overweight</td>
<td>109</td>
<td>39.9</td>
<td></td>
<td>72</td>
</tr>
<tr>
<td>Obese</td>
<td>61</td>
<td>21.9</td>
<td></td>
<td>81</td>
</tr>
<tr>
<td>One-Year Weight Change</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No change</td>
<td>115</td>
<td>41.2</td>
<td>0.1619</td>
<td>68</td>
</tr>
<tr>
<td>Decreased</td>
<td>87</td>
<td>31.1</td>
<td></td>
<td>78</td>
</tr>
<tr>
<td>Increased</td>
<td>64</td>
<td>22.9</td>
<td></td>
<td>50</td>
</tr>
<tr>
<td>Ten-Year Weight Change</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No change</td>
<td>45</td>
<td>16.1</td>
<td>0.1261</td>
<td>29</td>
</tr>
<tr>
<td>Decreased</td>
<td>111</td>
<td>39.8</td>
<td></td>
<td>77</td>
</tr>
<tr>
<td>Increased</td>
<td>112</td>
<td>40.1</td>
<td></td>
<td>96</td>
</tr>
<tr>
<td>Physical Activity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not Active</td>
<td>93</td>
<td>33.3</td>
<td>0.8197</td>
<td>58</td>
</tr>
<tr>
<td>Active</td>
<td>185</td>
<td>66.3</td>
<td></td>
<td>151</td>
</tr>
<tr>
<td>IADL Impairment</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not Impaired</td>
<td>188</td>
<td>67.4</td>
<td>0.0358</td>
<td>119</td>
</tr>
<tr>
<td>IADL Impaired</td>
<td>91</td>
<td>32.6</td>
<td></td>
<td>90</td>
</tr>
<tr>
<td>Self-Rated Health</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Excellent/VG/Good</td>
<td>192</td>
<td>68.9</td>
<td>0.0034</td>
<td>146</td>
</tr>
<tr>
<td>Fair</td>
<td>68</td>
<td>24.4</td>
<td></td>
<td>52</td>
</tr>
<tr>
<td>Poor</td>
<td>19</td>
<td>6.8</td>
<td></td>
<td>11</td>
</tr>
<tr>
<td>Presence of Appetite loss or Overeating</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>216</td>
<td>77.4</td>
<td>0.0962</td>
<td>141</td>
</tr>
<tr>
<td>Yes</td>
<td>55</td>
<td>19.7</td>
<td></td>
<td>63</td>
</tr>
</tbody>
</table>

aSI= Smell Impairment  
bn= Population size  
c %= population size (n) total percentage for the row
Table 5.47 Prevalence of the presence of smell impairment and smell alteration by other smell variables in participants 60+ years (N=1285)

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Smell Impairment: ‘SI&lt;sup&gt;a&lt;/sup&gt; Present’</th>
<th></th>
<th>Self-Reported Smell Alteration: ‘SA Present’</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n&lt;sup&gt;b&lt;/sup&gt;</td>
<td>%&lt;sup&gt;c&lt;/sup&gt;</td>
<td>P-value</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Smell Variables</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Smell Alteration/Impairment</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No SA/No SI</td>
<td>204</td>
<td>73.1</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>SA Present/Sl Present</td>
<td>75</td>
<td>26.9</td>
<td></td>
</tr>
<tr>
<td><strong>Persistent cold/flu last 12 months?</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>259</td>
<td>92.8</td>
<td>0.3747</td>
</tr>
<tr>
<td>Yes</td>
<td>20</td>
<td>7.1</td>
<td></td>
</tr>
<tr>
<td><strong>Broke Nose/Serious Injury to Face/Skull? (CSQ 204)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>196</td>
<td>70.3</td>
<td>0.1</td>
</tr>
<tr>
<td>Yes</td>
<td>81</td>
<td>29</td>
<td></td>
</tr>
<tr>
<td><strong>Frequent nasal congestion in past 12 month? (CSQ 240)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>237</td>
<td>84.9</td>
<td>0.7978</td>
</tr>
<tr>
<td>Yes</td>
<td>42</td>
<td>15.1</td>
<td></td>
</tr>
<tr>
<td><strong>Broke Nose/Serious Injury to Face/Skull? (CSQ 250)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>229</td>
<td>82.1</td>
<td>0.11</td>
</tr>
<tr>
<td>Yes</td>
<td>48</td>
<td>17.2</td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup>SI = Smell Impairment
<sup>b</sup>n = Population size
<sup>c</sup>% = population size (n) total percentage for the row
Table 5.48 Continuous variables means and p-values by smell impairment in participants

<table>
<thead>
<tr>
<th>Variable</th>
<th>No SI&lt;sup&gt;a&lt;/sup&gt;</th>
<th>SI Present</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n&lt;sup&gt;b&lt;/sup&gt;</td>
<td>Mean (SE)&lt;sup&gt;c&lt;/sup&gt;</td>
<td>n</td>
</tr>
<tr>
<td>Avrg. Handgrip Strength (kg)</td>
<td>1008</td>
<td>31.0 (0.54)</td>
<td>279</td>
</tr>
<tr>
<td>Current Weight (kg)</td>
<td>1000</td>
<td>81.4 (0.93)</td>
<td>273</td>
</tr>
<tr>
<td>Sedentary Hours (hr.)</td>
<td>1005</td>
<td>7.0 (0.11)</td>
<td>275</td>
</tr>
</tbody>
</table>

<sup>a</sup>SI = Smell Impairment  
<sup>b</sup>n = Population size  
<sup>c</sup>SE = Standard Error

Table 5.49 Continuous variables means and p-values by smell alteration in participants

<table>
<thead>
<tr>
<th>Variable</th>
<th>No SA&lt;sup&gt;a&lt;/sup&gt;</th>
<th>SA Present</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n&lt;sup&gt;b&lt;/sup&gt;</td>
<td>Mean (SE)&lt;sup&gt;c&lt;/sup&gt;</td>
<td>n</td>
</tr>
<tr>
<td>Avrg. Handgrip Strength (kg)</td>
<td>1078</td>
<td>30.7 (0.40)</td>
<td>209</td>
</tr>
<tr>
<td>Current Weight (hr.)</td>
<td>1068</td>
<td>80.3 (0.59)</td>
<td>205</td>
</tr>
<tr>
<td>Sedentary Hours (hr.)</td>
<td>1071</td>
<td>7.0 (0.11)</td>
<td>209</td>
</tr>
</tbody>
</table>

<sup>a</sup>SA = Smell Alteration  
<sup>b</sup>n = Population size  
<sup>c</sup>SE = Standard Error

**Scent and Smell Score Variables.** The analysis revealed that the ability to identify the scent of smoke was statistically significant (p<0.05) for gender, age, income, and education (Table 5.50). Similarly, the only variables from the health assessment that differed statistically were muscle strength classification and sedentary hours. For the grape scent, race, age, muscle strength classification, sedentary hours, and average handgrip strength were all significant (p<0.05). In general, gas scent values were
statistically significant with gender, age, smell alteration, muscle strength classification, average handgrip strength, and BMI.

Table 5.51 shows that smell impairment and the total score for the scent test variable had the same statistically significant variables for sociodemographic and health assessment characteristics. However, in addition to those variables, the scent total score was also significant ($p<0.05$) with income, current weight, average grip strength, and BMI – which were not significant in smell impairment ($p>0.05$).

Table 5.50 Individual scents from the scent test and their statistically significant interactions ($p<0.05^a$)

<table>
<thead>
<tr>
<th>Scent: Smoke (smoke_ST)</th>
<th>Gender</th>
<th>Age Cat.</th>
<th>Income</th>
<th>Smell Alt.</th>
<th>Educ.</th>
<th>Muscle Strength Class.</th>
<th>Sedentary Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scent: Grape (grape_ST)</td>
<td>Race</td>
<td>Age Cat.</td>
<td>Muscle Strength Class.</td>
<td>Sedentary Hours</td>
<td>Average Handgrip Strength</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scent: Gas (gas_ST)</td>
<td>Gender</td>
<td>Age Cat.</td>
<td>Smell Alt.</td>
<td>Muscle Strength Class.</td>
<td>Average Handgrip Strength</td>
<td>BMI Cat.</td>
<td></td>
</tr>
</tbody>
</table>

$^a$Variables not listed on the table had a $p$-value $>0.05$ (see Appendix E)
Table 5.51 Smell scores variables and their significant interactions (p<0.05a)

<table>
<thead>
<tr>
<th>Scent Test Totals (ST_totals)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
</tr>
<tr>
<td>Age Cat</td>
</tr>
<tr>
<td>Race</td>
</tr>
<tr>
<td>Educ.</td>
</tr>
<tr>
<td>Income</td>
</tr>
<tr>
<td>Smell Alt.</td>
</tr>
<tr>
<td>Rated Health</td>
</tr>
<tr>
<td>Muscle Strength Class.</td>
</tr>
<tr>
<td>Smell Alt. Totals</td>
</tr>
<tr>
<td>Sedentary Hours</td>
</tr>
<tr>
<td>Current Weight</td>
</tr>
<tr>
<td>Average Handgrip Strength</td>
</tr>
<tr>
<td>BMI Cat.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Smell Alteration Score Totals (smellalt_totals)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age Cat.</td>
</tr>
<tr>
<td>Smell Imp.</td>
</tr>
<tr>
<td>IADL Imp.</td>
</tr>
<tr>
<td>Scent Test Total Scores</td>
</tr>
<tr>
<td>Sedentary Hours</td>
</tr>
<tr>
<td>Current Weight</td>
</tr>
<tr>
<td>Average Handgrip Strength</td>
</tr>
<tr>
<td>BMI Cat.</td>
</tr>
</tbody>
</table>

aVariables not listed on the table had a p-value>0.05 (see Appendix E)

Health Assessment Variables

Table 5.52 list all of the variables that were statistically significant with the health assessment variables. Overall, gender and age were significantly associated with sedentary hours, average handgrip strength, and muscle strength classification (p<0.05). As expected, the average handgrip strength was associated with appetite, sedentary hours, and SMQ020 (smoking variable). BMI was associated with smell alteration total score and presence of smell alteration, but not with smell impairment (except for the
gas scent). Lastly, appetite changes and physical activity had significant interactions (p<0.05) with self-rated health.

Table 5.52 Health characteristic variables and their significant interactions (p-values<0.05a)

<table>
<thead>
<tr>
<th>Sedentary Hours</th>
<th>Gender, Age Cat., Race, Cohabitation Status, Smell Impairment, Scent Test Total Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>Socio-Demographic</td>
<td>Gender, Age Cat., Race, Cohabitation Status, Smoking</td>
</tr>
<tr>
<td>Health/Strength</td>
<td>Rated Health, IADL imp., Physical Activity, Muscle Strength Class, Average Handgrip Strength</td>
</tr>
<tr>
<td>Weight</td>
<td>Current weight</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Muscle Grip Test</th>
<th>Gender, Age Cat., Race, Educ., Cohabitation Status, Smoking, Scent Test Total Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Socio-Demographic</td>
<td>Gender, Age Cat., Race, Educ., Cohabitation Status, Smoking</td>
</tr>
<tr>
<td>Health/Strength</td>
<td>Rated Health, IADL imp., Physical Activity, Appetite, Sedentary Hours</td>
</tr>
<tr>
<td>Weight</td>
<td>Current weight</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Muscle Strength Categories</th>
<th>Gender, Age Cat., Cohabitation Status, Educ., Income, Scent Test Total Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Socio-Demographic</td>
<td>Gender, Age Cat., Cohabitation Status</td>
</tr>
<tr>
<td>Health/Strength</td>
<td>Rated Health, IADL Imp., Physical Activity</td>
</tr>
<tr>
<td>Weight</td>
<td>BMI Cat., Weight Change (10 years)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Categories of BMIb</th>
<th>Smell Alt., Smell Alt. Totals, Gas Scent, Scent Test Total Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Health/Strength</td>
<td>Rated Health, Appetite, IADL imp., Average Handgrip Test</td>
</tr>
</tbody>
</table>

| Appetitec                 | Rated Health                                                                         |

| Physical Activityd        | Rated Health                                                                         |

| Health/Strength           | Rated Health                                                                         |

---

aVariables not listed on the table had a p-value>0.05 (see Appendix)
bVariable tested only against smell and health assessment variables
cVariable tested only against age, physical activity, rated health, and appetite
For additional hypothesis testing of non-significant p-values of scent and smell scores selected variables and health assessment variables, refer to Appendix E.

**Regression Models**

**Logistic Regression Models**

**Smell Disorder Assessment**

**Selected Scents from Smell Test.**

Gas Scent. Table 5.53 displays the results of the stepwise multivariate logistic regression analysis of the association between failing to identify the gas scent and other health and smell assessment variables. Overall, variables associated with the risk were: smell alteration, BMI, average handgrip strength, gender, and age. Females are less likely to not identify the gas scent; being female decreased the odds by 46% (OR: 0.54, CI=0.40-0.80). For age, the only significant range was 75-80 years (p<0.05). Persons aged 75-80 were more likely to score ‘wrong,’ and that category increased the odds by 190% (OR=2.9, CI=2.12-4.29). After controlling for gender and age, adults who failed to identify the gas scent were more likely to have a smell alteration (OR=1.8, CI=1.10-3.10).

On the other hand, overall, BMI was statistically significant (p≤0.05), but only the ‘obese’ level had a significant interaction (p≤0.05), and lowered the odds of not indentifying the gas scent by 38% (OR: 0.62, CI:1.81-3.83). Lastly, an increase in the average handgrip test decreased the odds of failing to identify the gas smell (OR:0.96, CI:0.93-0.99). Similarly, the contrast estimate probability
(Table 5.54) shows that with an increase of 5 kg in the average handgrip, the probability of identifying gas incorrectly decreases gradually.

Smoke Scent. As shown in Table 5.55, the variables of age, gender, income, smell alteration, and sedentary hours were associated with the risk of not identifying smoke scent (p≤0.05). Females had 50% lower odds of identifying smoke incorrectly (OR: 0.50, CI: 0.40-0.70). For age, the only significant range was 75-80 (p<0.05), which increased the odds by 207% (OR:3.07, CI:1.90-4.90). Likewise, an income to poverty ratio of ‘>3.9’ decreased the odds of failing to identify smoke by 60% (OR:0.40, CI:0.23-0.77) when compared to '1.2-2.1' ratio. Similar to the gas scent, having a smell alteration present increased the risk of not recognizing the smell (OR: 2.14, CI:1.34-3.65). Lastly, for every unit increase in sedentary hours, the odds for ‘wrong’ smoke also increased (OR:1.09, CI:1.03-1.14).

Grape Scent. Overall, the variables associated with the risk of failing to identify the grape scent were age, race, smell alteration, and muscle strength classification. The range of 75-80 years increased the risk (OR:1.73, CI:1.34-2.23, Table 5.56). Similarly, having a smell alteration also increased the odds of identifying the smell incorrectly (OR:1.69, CI:1.15-2.51). On the other hand, race had an overall significant trend only (p≤0.05). Finally, having a normal muscle strength decreased the odds by 31% of failing to identify the grape scent (OR:0.69, CI:0.51-0.92).
Table 5.53 ORs and 95% CIs for the risk factors associated with failing to identify the scent gas from the smell test

<table>
<thead>
<tr>
<th>Variables (p-value)</th>
<th>Levels</th>
<th>Gas Scent n=1255</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender (p&lt;0.01)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>0.54</td>
<td>0.54</td>
</tr>
<tr>
<td></td>
<td>0.40-0.79</td>
<td>0.40-0.80</td>
</tr>
<tr>
<td>Age Cat. (p&lt;0.01)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>65-69(^b)</td>
<td>0.25(^b)</td>
<td>0.60-2.59(^b)</td>
</tr>
<tr>
<td></td>
<td>0.26(^b)</td>
<td>0.63-2.61(^b)</td>
</tr>
<tr>
<td>70-74(^b)</td>
<td>1.83(^b)</td>
<td>1.25-2.08(^b)</td>
</tr>
<tr>
<td></td>
<td>1.83(^b)</td>
<td>1.26-2.10(^b)</td>
</tr>
<tr>
<td>75-80</td>
<td>2.8</td>
<td>1.19-2.48</td>
</tr>
<tr>
<td></td>
<td>2.9</td>
<td>2.12-4.29</td>
</tr>
<tr>
<td>Smell Alteration (p=0.02)</td>
<td>SA Present</td>
<td>1.7</td>
</tr>
<tr>
<td>Current Weight</td>
<td>&gt;0.05(^b)</td>
<td>&gt;0.05(^b)</td>
</tr>
<tr>
<td></td>
<td>0.99</td>
<td>0.99-1.00</td>
</tr>
<tr>
<td>BMI Cat. (p&lt;0.01)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Obese</td>
<td>0.57</td>
<td>0.44-0.74</td>
</tr>
<tr>
<td></td>
<td>0.62</td>
<td>1.81-3.83</td>
</tr>
<tr>
<td>Overweight(^b)</td>
<td>0.73(^b)</td>
<td>0.47-1.15(^b)</td>
</tr>
<tr>
<td></td>
<td>0.67(^b)</td>
<td>0.40-1.18(^b)</td>
</tr>
<tr>
<td>Underweight(^b)</td>
<td>1.29(^b)</td>
<td>0.59-2.78(^b)</td>
</tr>
<tr>
<td></td>
<td>1.49(^b)</td>
<td>0.67-3.22(^b)</td>
</tr>
<tr>
<td>Avrg. Hand Grip Strength (p&lt;0.01)</td>
<td>0.98</td>
<td>.93-.98</td>
</tr>
</tbody>
</table>

\(^a\)Adjusted for gender and age  
\(^b\)Not statistically significant (p>0.05)

Table 5.54 Contrast estimate probability for gas scent and average handgrip strength (and age and gender)

<table>
<thead>
<tr>
<th>Contrast by kg</th>
<th>Estimate Probability (SE)</th>
<th>95% CI</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>0.34 (0.07)</td>
<td>0.22-0.49</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>10</td>
<td>0.31 (0.06)</td>
<td>0.21-0.43</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>15</td>
<td>0.28 (0.05)</td>
<td>0.20-0.3</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>20</td>
<td>0.24 (0.04)</td>
<td>0.18-0.32</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>25</td>
<td>0.22 (0.03)</td>
<td>0.16-0.28</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>30</td>
<td>0.19 (0.03)</td>
<td>0.14-0.24</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>35</td>
<td>0.17 (0.02)</td>
<td>0.12-0.22</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>40</td>
<td>0.14 (0.02)</td>
<td>0.10-0.20</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>45</td>
<td>0.13 (0.03)</td>
<td>0.08-0.19</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>
Table 5.55 ORs and 95% CIs for the risk factors associated with failing to identify the scent smoke from the smell test

<table>
<thead>
<tr>
<th>Variables (p-value)</th>
<th>Levels</th>
<th>Crude</th>
<th>Adjusted&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>OR</td>
<td>95% CI</td>
</tr>
<tr>
<td>OR</td>
<td>95% CI</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender (&lt;0.01)</td>
<td>Female</td>
<td>0.56</td>
<td>0.40-0.79</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.50</td>
<td>0.40-0.70</td>
</tr>
<tr>
<td>Age Cat (&lt;0.01)</td>
<td>65-69</td>
<td>0.73</td>
<td>0.35-1.56</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.64</td>
<td>0.31-1.40</td>
</tr>
<tr>
<td></td>
<td>70-74</td>
<td>0.11&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.84-3.14&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.10&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.60-2.44&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>75-80</td>
<td>3.92</td>
<td>2.56-5.99</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.07</td>
<td>1.90-4.90</td>
</tr>
<tr>
<td>Income (&lt;0.01)</td>
<td>2.2-3.9</td>
<td>0.67&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.39-1.19&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>&lt;1.2</td>
<td>0.62&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.40-0.96&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>&gt;3.9</td>
<td>0.35</td>
<td>0.18-0.69</td>
</tr>
<tr>
<td>Smell Alteration (&lt;0.01)</td>
<td>SA Present</td>
<td>2.02</td>
<td>1.2-3.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.14</td>
<td>1.34-3.65</td>
</tr>
<tr>
<td>Sedentary Hours (&lt;0.01)</td>
<td></td>
<td>1.09</td>
<td>1.03-1.14</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.09</td>
<td>1.03-1.14</td>
</tr>
</tbody>
</table>

<sup>a</sup>Adjusted for gender, age and income

<sup>b</sup>Not statistically significant (p>0.05)
Table 5.56 ORs and 95% CIs for the risk factors associated with failing to identify the scent grape from the smell test

<table>
<thead>
<tr>
<th>Variables (p-value)</th>
<th>Levels</th>
<th>Crude</th>
<th>Adjusted&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>OR</td>
<td>95% CI</td>
</tr>
<tr>
<td>Gender</td>
<td>Female</td>
<td>0.73&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.28-0.54&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>Age Cat. (&lt;0.01)</td>
<td>65-69</td>
<td>1.16&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>70-74</td>
<td>1.06&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>75-80</td>
<td>1.56</td>
</tr>
<tr>
<td>Race (&lt;0.01)</td>
<td>Mexican American</td>
<td>2.06&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.50-3.09&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>NH Black</td>
<td>2.09&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.40-3.17&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>Other Hispanic</td>
<td>2.18&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.35-3.82&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>Other race</td>
<td>1.89&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.89-3.40&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Smell Alt. (&lt;0.01)</td>
<td>SA Present</td>
<td>1.59</td>
<td>1.07-2.35</td>
</tr>
<tr>
<td>Muscle Strength Class. (&lt;0.01)</td>
<td>Normal</td>
<td>0.59</td>
<td>0.45-0.79</td>
</tr>
</tbody>
</table>

<sup>a</sup>Adjusted for gender, age and income  
<sup>b</sup>Not statistically significant (p>0.05)

Smell Impairment. Table 5.57 displays the results of the stepwise multivariate logistic regression analysis of the association between smell impairment, health assessment variables and smell alteration. Overall, the following variables had a significant association with the risk for the disorder: gender, age, race, education, rated
health, muscle strength classification, average handgrip strength, sedentary hours, and smell alteration. Females had a decreased risk when compared to males (OR:0.54, CI:0.40-0.80). The model also showed that trend for race was significant (<0.01), but no specific races in the adjusted model were statistically significant (p>0.05). For age, the only range with significance (p<0.05 and CI not equal to 1) was 75-80, which had 251% higher odds of having a smell impairment when compared to those in the 60-64 years range (OR:3.51, CI:2.51-3.11). Similarly, older adults with an education of ‘high school or less’ were more likely to have a smell impairment when compared to those with an education level of ‘college or more’; the odds of having a smell impairment are 70% higher for ‘high school or less’ (OR:1.70, CI:1.40-2.30).

After controlling for age and gender, older adults with smell impairment were more likely to have ‘poor’ self-rated health (OR:2.63, CI:1.30-5.40); a ‘fair’ level of self-rated health was not significantly related (p>0.05). An increase in sedentary hours was also associated with an increased risk for smell impairment (OR:1.07, CI:1.03-1.11). Older adults with ‘normal’ muscle strength were less likely to have smell impairment when compared to those with ‘below normal’ strength; (OR:0.52, CI:0.33-0.90).

Likewise, an increase of hand grip strength was associated with a reduced risk of smell alteration. The odds were lowered by a factor of 0.96 (OR:0.96, CI:0.93-0.99). Lastly, Table 5.55 also shows that older adults with a smell alteration were more likely to have a smell impairment (OR: 3.0, CI:2.10-4.60).
Table 5.57 ORs and 95% CIs for the risk factors associated with the presence of a smell impairment (‘SI Present’)

<table>
<thead>
<tr>
<th>Variables (p-value)</th>
<th>Levels</th>
<th>Crude OR</th>
<th>95% CI</th>
<th>Adjusteda OR</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender (&lt;0.01)</td>
<td>Female</td>
<td>0.59</td>
<td>0.38-0.91</td>
<td>0.54</td>
<td>0.40-0.80</td>
</tr>
<tr>
<td>Age Cat (&lt;0.01)</td>
<td>65-69</td>
<td>0.88</td>
<td>0.54-1.44</td>
<td>0.86</td>
<td>0.51-1.50</td>
</tr>
<tr>
<td></td>
<td>70-74</td>
<td>1.19b</td>
<td>0.58-2.44</td>
<td>1.10</td>
<td>0.62-2.44</td>
</tr>
<tr>
<td></td>
<td>75-80</td>
<td>3.3</td>
<td>2.02-4.40</td>
<td>3.51</td>
<td>2.07-5.95</td>
</tr>
<tr>
<td>Educ. (&lt;0.01)</td>
<td>High School or Less</td>
<td>1.87</td>
<td>1.46-2.40</td>
<td>1.70</td>
<td>1.40-2.30</td>
</tr>
<tr>
<td>Race (&lt;0.01)</td>
<td>Mexican American</td>
<td>1.02</td>
<td>0.63-1.67</td>
<td>1.11b</td>
<td>0.59-2.07b</td>
</tr>
<tr>
<td></td>
<td>NH Black</td>
<td>1.80b</td>
<td>1.00-3.15b</td>
<td>1.81b</td>
<td>1.04-3.16b</td>
</tr>
<tr>
<td></td>
<td>Other Hispanic</td>
<td>2.07b</td>
<td>1.02-1.52b</td>
<td>2.17b</td>
<td>1.03-1.53b</td>
</tr>
<tr>
<td></td>
<td>Other race</td>
<td>2.42b</td>
<td>1.32-4.60b</td>
<td>2.44b</td>
<td>1.30-4.63b</td>
</tr>
<tr>
<td>Rated Health (&lt;0.01)</td>
<td>Fair</td>
<td>1.81b</td>
<td>1.27-2.58b</td>
<td>1.57b</td>
<td>1.13-2.13b</td>
</tr>
<tr>
<td></td>
<td>Poor</td>
<td>2.96</td>
<td>1.6-5.5</td>
<td>2.63</td>
<td>1.30-5.40</td>
</tr>
<tr>
<td>IADL Impairmentc</td>
<td>Not impaired</td>
<td>0.6</td>
<td>0.4-0.9</td>
<td>0.69b</td>
<td>0.46-1.06b</td>
</tr>
<tr>
<td>Muscle Strength Class. (&lt;0.01)</td>
<td>Normal</td>
<td>0.36</td>
<td>0.21-0.64</td>
<td>0.52</td>
<td>0.33-0.90</td>
</tr>
<tr>
<td>Smell Alteration (&lt;0.01)</td>
<td>SA Present</td>
<td>2.5</td>
<td>1.6-4.0</td>
<td>3.00</td>
<td>2.10-4.60</td>
</tr>
<tr>
<td>Sedentary Hours (&lt;0.01)</td>
<td></td>
<td>1.07</td>
<td>1.6-4.0</td>
<td>1.07</td>
<td>1.03-1.11</td>
</tr>
<tr>
<td>Avrg. Hand Grip Strengthd</td>
<td></td>
<td>0.98b</td>
<td>0.96-1.01b</td>
<td>0.96</td>
<td>0.93-0.99</td>
</tr>
</tbody>
</table>

aAdjusted for gender, age and income
bNot statistically significant (p>0.05)

p<0.05 for the crude model and p>0.05 for the adjusted

p>0.05 for the crude and p<0.05 for the adjusted
Smell Alteration. The sociodemographic and health assessment variables associated with the risk for the presence of a smell alteration were: age, BMI, and IADL impairment. While the number of sedentary hours was significant \( (p < 0.05) \) when adjusted for age, its CI included 1, which made the interaction not significant \( (p > 0.05) \). BMI and age were significantly associated with smell alteration \( (p < 0.05) \), but none of the individual levels differed significantly \( (p > 0.05) \). The health assessment variable of IADL imp. was the only one associated with the risk of smell impairment. As shown in Table 5.56, the odds of a smell alteration are 51% lower among those who were not impaired \( (OR: 0.47, CI: 0.32-0.68) \).

Table 5.58 OR and 95% CI for risk factors associated with the presence of a smell alteration

<table>
<thead>
<tr>
<th>Variables (p-value)</th>
<th>Levels</th>
<th>Crude</th>
<th>Adjusted&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>OR</td>
<td>95% CI</td>
</tr>
<tr>
<td>Gender (&gt;0.05)</td>
<td>Female</td>
<td>p&gt;0.05</td>
<td>p&gt;0.05</td>
</tr>
<tr>
<td>Age Cat (&lt;0.01)</td>
<td>65-69</td>
<td>p&gt;0.05</td>
<td>p&gt;0.05</td>
</tr>
<tr>
<td></td>
<td>70-74</td>
<td>p&gt;0.05</td>
<td>p&gt;0.05</td>
</tr>
<tr>
<td></td>
<td>75-80</td>
<td>p&gt;0.05</td>
<td>p&gt;0.05</td>
</tr>
<tr>
<td>BMI Cat. (&lt;0.01)</td>
<td>Obese</td>
<td>p&gt;0.05</td>
<td>p&gt;0.05</td>
</tr>
<tr>
<td></td>
<td>Overweight</td>
<td>p&gt;0.05</td>
<td>p&gt;0.05</td>
</tr>
<tr>
<td></td>
<td>Underweight</td>
<td>p&gt;0.05</td>
<td>p&gt;0.05</td>
</tr>
<tr>
<td>IADL Imp. (&lt;0.01)</td>
<td>Not Impaired</td>
<td>0.49&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.30-0.70&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.47&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.32-0.68&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Sedentary Hours&lt;sup&gt;b&lt;/sup&gt;</td>
<td>p&gt;0.05</td>
<td>p&gt;0.05</td>
<td>1.08&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Current Weight (&lt;0.05)</td>
<td>1.01&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1.00-1.03&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1.013&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>a</sup>Adjusted for age and gender.

<sup>b</sup>p>0.05 for the crude model and p<0.05 for the adjusted model

<sup>c</sup>p≤0.05
Linear Regression Models

**Smell Disorder Assessment**

**Scent Test Total Score.** The total score from the smell test was significantly associated with age, gender, race, income, rated health, muscle strength classification, current weight, smell alteration score, smell alteration, sedentary hours and average handgrip test (Table 5.59). Persons in the age range 60-64 had a higher total score when compared to those 70-74 (Est: 0.26, Table 5.59). Males had a lower total score (Est: -0.44). Race and BMI were not significantly related in the crude model (p>0.05) but became significant (p<0.05) when adjusted for age, gender, and income. In the adjusted model, ‘Mexican Americans’ had a higher total score than ‘Other Hispanics’ (Est: 0.33). None of the BMI levels were significantly related (p>0.05) to the total smell score.

Additionally, a lower income ratio was affiliated in a lower smell score (Table 5.59). Having normal self-rated health (vs. poor) was associated with an increased total score (Est: 0.52). Additionally, normal muscle strength had higher estimates than below normal (Est: 0.46). A higher smell alteration score (3 vs. 0) and the presence smell alteration were related to lower total scent scores by approximately 0.30 and 0.60 respectively.

**Smell Alteration Total Score.** Age, smell impairment, IADL impairment, BMI, current weight, sedentary hours, average handgrip strength, and scent total scores were associated with the smell alteration total score (Table 5.60). Being in the age range of 60-64 (compared to 75-80) and not having a smell impairment were associated with lower smell alteration totals (Est: -0.09 and Est: -0.18, respectively). Additionally, the
smell alteration score was related to being IADL impaired and being ‘underweight’: both raised the total score (0.07 and 0.12 increased respectively). Lastly, Table 5.60 shows that while the total scent smell test variable was significantly associated with smell alteration total score ($p < 0.05$), none individual scent scores (0-8 levels) were significantly related.

Table 5.59 Smell Test Total Score crude (unadj.) and adjusted estimates and $p$-values

<table>
<thead>
<tr>
<th>Variables (p-value)</th>
<th>Values</th>
<th>Crude Estimate</th>
<th>Adjusted Estimate$^a$</th>
<th>Level p-values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age Cat.$^c$</td>
<td>60-64 vs 75-80</td>
<td>0.80</td>
<td>0.44</td>
<td>0.0006</td>
</tr>
<tr>
<td></td>
<td>60-64 vs 70-74</td>
<td>0.28</td>
<td>0.26</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td></td>
<td>60-64 vs 65-69</td>
<td>0.15</td>
<td>0.15</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Gender (&lt;0.001)</td>
<td>M vs F</td>
<td>-0.43</td>
<td>-0.44</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Race$^d$</td>
<td>Mex Am. vs NH Black</td>
<td>p&gt;0.05$^b$</td>
<td>0.30</td>
<td>0.78</td>
</tr>
<tr>
<td></td>
<td>Mex Am. vs NH White</td>
<td>p&gt;0.05$^b$</td>
<td>-0.20</td>
<td>0.12</td>
</tr>
<tr>
<td></td>
<td>Mex Am. vs Other Hispanic</td>
<td>p&gt;0.05$^b$</td>
<td>0.33</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Income$^c$</td>
<td>&lt;1.2 vs &gt;3.9</td>
<td>p&gt;0.05$^b$</td>
<td>-0.25</td>
<td>0.03$^c$</td>
</tr>
<tr>
<td></td>
<td>&lt;1.2 vs 2.2-3.9</td>
<td>-0.29</td>
<td>-0.23</td>
<td>0.05</td>
</tr>
<tr>
<td></td>
<td>&lt;1.2 vs 1.2-2.2</td>
<td>-0.29</td>
<td>-0.23</td>
<td>0.02</td>
</tr>
<tr>
<td>Rated Health$^c$</td>
<td>Normal vs Poor</td>
<td>0.230</td>
<td>0.52</td>
<td>0.03</td>
</tr>
<tr>
<td></td>
<td>Normal vs Fair</td>
<td>0.22</td>
<td>0.46</td>
<td>0.067</td>
</tr>
<tr>
<td>BMI Cat$^e$</td>
<td>Obese</td>
<td>0.38</td>
<td>0.38</td>
<td>&gt;0.07</td>
</tr>
<tr>
<td></td>
<td>Overweight</td>
<td>0.12</td>
<td>0.12</td>
<td>&gt;0.23</td>
</tr>
<tr>
<td></td>
<td>Underweight</td>
<td>0.09</td>
<td>0.09</td>
<td>&gt;0.71</td>
</tr>
<tr>
<td>Muscle Strength Class.$^c$</td>
<td>Normal vs Below Normal</td>
<td>0.68</td>
<td>0.46</td>
<td>0.0003</td>
</tr>
<tr>
<td>Current Weight$^c$</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Smell Alt. Total Score</td>
<td>3 vs 0</td>
<td>-0.40</td>
<td>-0.30</td>
<td>0.06</td>
</tr>
<tr>
<td></td>
<td>2 vs 0</td>
<td>-0.62</td>
<td>-0.58</td>
<td>0.004</td>
</tr>
<tr>
<td>Smell Alteration$^c$</td>
<td>SA vs No SA</td>
<td>-0.56</td>
<td>-0.61</td>
<td>0.0156</td>
</tr>
<tr>
<td>Sedentary Hours$^c$</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Avrg. Handgrip Strength$^c$</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

$^a$Adjusted for age, gender, race and income  
$^b$p>0.05 in the linear regression model  
$^c$p<0.05 in the linear regression model  
$^d$p>0.05 in the crude model, p<0.05 in the adjusted model  
$^e$p<0.05 in the crude model, p>0.05 in the adjusted model
Table 5.60 Smell Alteration Total Score crude and adjusted estimates and p-values

<table>
<thead>
<tr>
<th>Variables (p-value)</th>
<th>Values</th>
<th>Crude Estimate</th>
<th>Adjusted Estimate</th>
<th>Level p-values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender (&lt;0.05)</td>
<td>M vs F</td>
<td>0.03</td>
<td>0.02</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Age Cat. (&lt;0.001)</td>
<td>60-64 vs 75-80</td>
<td>-0.09</td>
<td>-0.09</td>
<td>0.0006</td>
</tr>
<tr>
<td></td>
<td>60-64 vs 70-74</td>
<td>-0.04</td>
<td>-0.04</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td></td>
<td>60-64 vs 65-69</td>
<td>-0.08</td>
<td>-0.08</td>
<td>0.044</td>
</tr>
<tr>
<td>Smell Imp. (&lt;0.01)</td>
<td>No SI vs SI</td>
<td>-0.16</td>
<td>-0.18</td>
<td>0.0018</td>
</tr>
<tr>
<td>IADL Imp. (&lt;0.01)</td>
<td>IADL vs NO IADL</td>
<td>0.14</td>
<td>0.07</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>BMI Cat. &lt;0.02)</td>
<td>Obese vs Normal</td>
<td>0.02</td>
<td>0.02</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td></td>
<td>Overweight vs Normal</td>
<td>0.07</td>
<td>0.06</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td></td>
<td>Underweight vs Normal</td>
<td>0.13</td>
<td>0.12</td>
<td>0.0124</td>
</tr>
<tr>
<td>Current Weight (&lt;0.01)</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Avrg. Handgrip Strength (&lt;0.02)</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>&lt;0.02</td>
</tr>
<tr>
<td>Scent Smell Test Total Score (&lt;0.01)</td>
<td>0 vs 8</td>
<td>-0.35</td>
<td>-0.44</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td></td>
<td>0 vs 7</td>
<td>-0.36</td>
<td>-0.44</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td></td>
<td>0 vs 6</td>
<td>-0.36</td>
<td>-0.43</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td></td>
<td>0 vs 5</td>
<td>-0.27</td>
<td>-0.33</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td></td>
<td>0 vs 4</td>
<td>-0.14</td>
<td>-0.19</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td></td>
<td>0 vs 3</td>
<td>-0.04</td>
<td>-0.06</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td></td>
<td>0 vs 2</td>
<td>-0.01</td>
<td>-0.08</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td></td>
<td>0 vs 1</td>
<td>-0.35</td>
<td>-0.39</td>
<td>&gt;0.05</td>
</tr>
</tbody>
</table>

\(^a\)Adjusted for age and gender

Health Assessment

Average Handgrip Strength. The sociodemographic variables of gender, age, education, and race had associations with the average handgrip strength. According to the model, males had average strengths that were 14.90 kg higher than those of women. Similarly, the 60-64 age range (vs. 75-80) had a higher handgrip (7.42 kg), and the wider the age gaps, the greater the mean estimates. Additionally, adults with 'high
school or less' for education had 1.25 kg lower average handgrip score. 'Mexican Americans' had larger means than Hispanics (Est: 1.10), but no other racial differences were found.

Self-rated health, BMI, physical activity, IADL impairment, current weight, sedentary hours, smell impairment, and scent test total score were associated with average handgrip strength. Normal self-rated health (vs. poor) and those physically active had higher averages (Est: 3.21 kg and Est: 1.31 kg respectively). Table 5.61 shows that ‘normal’ BMI is associated with an increased handgrip strength. Persons with an IADL and smell impaired had a significantly lower handgrip strength averages (Est: -2.12, Est: -1.65). Finally, wider ranges of scores for the scent test score variable were associated with increased handgrip strength averages (Table 5.61). However, the only levels (scores) significantly associated with handgrip strength were: 8 vs 0 (Est: 3.63), 7 vs 0 (Est: 2.06), 6 vs 0 (Est: 3.00), 5 vs 0 (Est: 2.14).

Sedentary Hours. Overall, the number of sedentary hours was related to cohabitation status, gender, age, race, rated health, IADL impairment, physically active, muscle strength classification, current weight, average handgrip strength, and scent test total score. In Table 5.60, living alone was associated with an increase of 0.78 of sedentary hours. Males (Est: 0.26) had higher estimates than females. Age had a significant trend (p<0.05) but no other significant relationships were observed (p>0.05). For race, ‘Mexican American’ vs. ‘Other Hispanic’ had the lowest estimates (Est:-0.25). Older adults who had ‘excellent’/ ’VG’/’Good’ self-rated health had lower hours of sedentary estimates than those with normal self-rate (Est: -0.23). Persons who were not
physically active and IADL impaired had higher estimates (Table 5.60) while those with normal strength had lower estimates for hours of sedentary activity (Est: -0.38).

Appendix F has a complete list of all the variables that were tested on the logistic and linear regression models and their significance.

Table 5.61 Average Handgrip strength crude and adjusted estimates and p-values

<table>
<thead>
<tr>
<th>Variables (p-value)</th>
<th>Values</th>
<th>Crude Estimate</th>
<th>Adjusted Estimate&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Level p-values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender (&lt;0.01)</td>
<td>M vs F</td>
<td>14.93</td>
<td>14.90</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Age Cat (&lt;0.01)</td>
<td>60-64 vs 75-80</td>
<td>7.24</td>
<td>7.42</td>
<td>&lt;0.0002</td>
</tr>
<tr>
<td></td>
<td>60-64 vs 70-74</td>
<td>3.61</td>
<td>2.83</td>
<td>&lt;0.0003</td>
</tr>
<tr>
<td></td>
<td>60-64 vs 65-69</td>
<td>1.75</td>
<td>1.65</td>
<td>&lt;0.0004</td>
</tr>
<tr>
<td>Educ. (&lt;0.01)</td>
<td>&lt;HS vs &gt;College</td>
<td>-2.65</td>
<td>-1.25</td>
<td>0.0043</td>
</tr>
<tr>
<td>Race (&lt;0.01)</td>
<td>Mex. vs NH Black</td>
<td>-0.36</td>
<td>0.76</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td></td>
<td>Mex. vs NH White</td>
<td>-2.86</td>
<td>0.63</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td></td>
<td>Mex Am. vs Other Hispanic</td>
<td>-3.69</td>
<td>1.10</td>
<td>0.0017</td>
</tr>
<tr>
<td>Rated Health (&lt;0.01)</td>
<td>Normal vs Poor</td>
<td>0.19</td>
<td>3.21</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td></td>
<td>Normal vs Fair</td>
<td>2.62</td>
<td>1.64</td>
<td>0.0045</td>
</tr>
<tr>
<td>BMI Cat. (&lt;0.001)</td>
<td>Normal vs Obese</td>
<td>8.24</td>
<td>4.25</td>
<td>0.0005</td>
</tr>
<tr>
<td></td>
<td>Normal vs Overweight</td>
<td>0.76</td>
<td>0.38</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td></td>
<td>Normal vs Underweight</td>
<td>3.80</td>
<td>1.55</td>
<td>0.0145</td>
</tr>
<tr>
<td>Physical Activity (&lt;0.01)</td>
<td>Active vs Inactive</td>
<td>3.01</td>
<td>1.32</td>
<td>0.0137</td>
</tr>
<tr>
<td>IADL Imp. (&lt;0.008)</td>
<td>IADL vs No IADL</td>
<td>-3.34</td>
<td>-2.12</td>
<td>0.0081</td>
</tr>
<tr>
<td>Current Weight (&lt;0.001)</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Sedentary Hours (&lt;0.001)</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Smell Imp&lt;sup&gt;b,c&lt;/sup&gt;</td>
<td>SI vs No SI</td>
<td>-1.35&lt;sup&gt;b&lt;/sup&gt;</td>
<td>-1.65&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.0178&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Scent Smell Test Total Scores (&lt;0.01)</td>
<td>8 vs 0</td>
<td>-0.03</td>
<td>3.63</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td></td>
<td>7 vs 0</td>
<td>-1.35</td>
<td>2.06</td>
<td>0.0087</td>
</tr>
<tr>
<td></td>
<td>6 vs 0</td>
<td>0.04</td>
<td>3.00</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td></td>
<td>0 vs 5</td>
<td>-2.27</td>
<td>2.14</td>
<td>0.0112</td>
</tr>
<tr>
<td></td>
<td>4 vs 0</td>
<td>-2.39</td>
<td>0.60</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td></td>
<td>3 vs 0</td>
<td>-2.28</td>
<td>0.69</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td></td>
<td>2 vs 0</td>
<td>2.69</td>
<td>-0.77</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td></td>
<td>1 vs 0</td>
<td>-4.15</td>
<td>-4.05</td>
<td>&gt;0.05</td>
</tr>
</tbody>
</table>

<sup>a</sup>Adjusted for gender, age, education and race  
<sup>b</sup>p>0.05 for the crude model  
<sup>c</sup>p<0.05 for the adjusted model
Table 5.62 Sedentary Hours crude and adjusted (adj.) estimates (est.) and p-values

<table>
<thead>
<tr>
<th>Variables (P-value)</th>
<th>Values</th>
<th>Crude Est.</th>
<th>Adj.(^a) Estimate(^*)</th>
<th>Level P-values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cohabitation Status</td>
<td>Living alone vs with Someone</td>
<td>0.80</td>
<td>0.78</td>
<td>0.0006</td>
</tr>
<tr>
<td>Gender (&gt;0.05-crude, &lt;0.01-adj.)</td>
<td>M vs F</td>
<td>0.28</td>
<td>0.26</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Age Cat. (&lt;0.001)</td>
<td>60-64 vs 75-80</td>
<td>0.15</td>
<td>0.15</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td></td>
<td>60-64 vs 70-74</td>
<td>-0.43</td>
<td>-0.44</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td></td>
<td>60-64 vs 65-69</td>
<td>&gt;0.05</td>
<td>0.30</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Race (&lt;0.001)</td>
<td>Mex American vs NH Black</td>
<td>&gt;0.05</td>
<td>-0.19</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td></td>
<td>Mex American vs NH White</td>
<td>&gt;0.05</td>
<td>0.33</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td></td>
<td>Mex American vs Other Hispanic</td>
<td>-0.40</td>
<td>-0.25</td>
<td>&gt;0.05(^b)</td>
</tr>
<tr>
<td>Rated Health (&lt;0.05)</td>
<td>Normal vs Poor</td>
<td>-0.29</td>
<td>-0.23</td>
<td>0.0468</td>
</tr>
<tr>
<td></td>
<td>Normal vs Fair</td>
<td>-0.29</td>
<td>-0.23</td>
<td>0.0201</td>
</tr>
<tr>
<td>IADL Imp. &lt;0.05)</td>
<td>IADL vs No IADL</td>
<td>0.63</td>
<td>0.21</td>
<td>0.0257</td>
</tr>
<tr>
<td>Physical Activity (&lt;0.01)</td>
<td>Active vs Not Active</td>
<td>0.29</td>
<td>0.13</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Muscle Strength Class. (&lt;0.01)</td>
<td>Normal vs Below Normal</td>
<td>0.38</td>
<td>0.38</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Current Weight</td>
<td>n/a</td>
<td>0.12</td>
<td>0.12</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Avrg. Hand Grip Strength</td>
<td>n/a</td>
<td>0.09</td>
<td>0.09</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Scent Smell Test Total Score (&lt;0.01)</td>
<td>0 vs 8</td>
<td>0.68</td>
<td>0.46</td>
<td>0.0003</td>
</tr>
<tr>
<td></td>
<td>0 vs 7</td>
<td>n/a</td>
<td>n/a</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td></td>
<td>0 vs 6</td>
<td>-0.40</td>
<td>-0.24</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td></td>
<td>0 vs 5</td>
<td>-0.62</td>
<td>-0.58</td>
<td>0.004</td>
</tr>
<tr>
<td></td>
<td>0 vs 4</td>
<td>-0.56</td>
<td>-0.61</td>
<td>0.0156</td>
</tr>
<tr>
<td></td>
<td>0 vs 3</td>
<td>n/a</td>
<td>n/a</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td></td>
<td>0 vs 2</td>
<td>n/a</td>
<td>n/a</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td></td>
<td>0 vs 1</td>
<td>1.72</td>
<td>1.84</td>
<td>&gt;0.05</td>
</tr>
</tbody>
</table>

\(^a\)Adjusted for gender, race and age
\(^b\)p>0.05 for the crude model and p<0.05 for the adjusted model
CHAPTER 6
DISCUSSION

Socio-demographic Data

The distribution of socio-demographic characteristics was similar to the 2010 U.S Census. For instance, our estimates for race showed that the lowest percentage was ‘Other Hispanic’ and highest was ‘NH White’ and that females and males were both close to 50% (Table 6.1). As expected, the age range with the highest percentage was 60-64; there is a higher percentage of the population in the range (U.S Census, 2010). In a lot of the variable interactions, race had an overall significance (p<0.05); however, none of its categories were significant (p>0.05). A possible reason for this finding is that in some categories the number of individuals was sparse (i.e. ‘Other Hispanic’ and ‘Other Race’) when compared to other categories (i.e. ‘NH White’ and ‘NH Black’).

Table 6.1 Comparison between 2010 U.S Census estimated (%) and this study

<table>
<thead>
<tr>
<th>Variable</th>
<th>US Census (%)</th>
<th>Study (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Race</td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>72</td>
<td>52.7</td>
</tr>
<tr>
<td>Black</td>
<td>13</td>
<td>20.9</td>
</tr>
<tr>
<td>Other races</td>
<td>15</td>
<td>26.4</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>49.1</td>
<td>49.7</td>
</tr>
<tr>
<td>Female</td>
<td>50.9</td>
<td>50.3</td>
</tr>
</tbody>
</table>

Selected Health Assessment Variables

Weight

Weight and weight loss are significant factors related to the general health status and quality of life within this population. Losses in body weight can have significant adverse effects on mobility, lean muscle mass, and bone mineral density and
is associated with many later-in-life conditions, including depression and cognitive impairment (Diehr et al., 1998; Harris et al., 1993; Pamuk et al., 1993; Losonczy et al., 1995; Sohrabi et al., 2015). Weight loss has also been theorized to be a potential non-cognitive indicator of Alzheimer’s disease. Given these effects and associations, an older adult’s weight and the ability to maintain it is one of the leading health concerns, especially since studies have shown that weight loss is expected with aging (Landi et al., 2016; Thomas, 2005).

We also observed self-reported weight loss with age in our study sample and found that current weight and BMI decreased as age increased. As mentioned previously, researchers have proposed that from age 60-70, there is an increase in weight while weight decreases after 70 (Rolls et al., 1994). This change is consistent with the fact that for the variable of weight change over the past ten-years almost half of the sample reported an increase in weight (Table 5.9), and with the fact that the age range of 75-80 had the highest percentage for ten-year weight decrease and ‘no change’ (26.4% and 30.2% respectively) while 60-64 had the highest percentage for ‘increased’ (37.9%).

Similarly, overweight and obese BMI categories had the highest number of participants in our study. However, it is essential to remember that BMI is a suboptimal measure of obesity in older adults. According to Gill et al., one of the reasons for that is that age-typical loss of height due to vertebral body compression and angulation of the spine causes BMI values to overestimate fatness; another reason is that BMI does not account for fat distribution (Gill, Bartels & Batsis, 2015). Because of that, BMI has been
discouraged for use in older adults as it does not "account for age-related changes in adipose tissue concerning the ratio between fat mass and fat-free mass" (Gill, Bartels & Batsis, 2015).

**Average Handgrip/Muscle Strength**

The handgrip test represents a validated, easy to administer, and reliable dynamic indicator of muscle mass and function which can, in turn, be an indicator of functional as well as nutritional status in the elderly (Wang et al., 2017). Grip strength has been recommended as an indicator of overall muscle strength (Wang et al., 2017) and as a biomarker of overall health status. The importance of understanding and seeing the effects of grip strength is that in disease, reduced muscle function has severe consequences for functional status. For instance, Norman et al. (2010) established a link between reduced handgrip strength and postoperative complications, increased length of hospital stay, loss of functional status, and survival in patients.

The average handgrip strength of our study sample was 30.1 kg and ranged from 3.2-62.4 kg, which was in accordance with previous studies. (Looker & Wang, 2015). The wide age range of 60 to 80 years present in our research could help explain the varied muscle strength in our results. Similarly, results for muscle strength classification also showed that the majority of the study sample had a normal grip strength. This is consistent with the National Center for Health Statistics (NCHS) data brief, where 18% of those aged 60 and older had below normal strength (Looker & Wang, 2015). For our study, those with ‘high school or less’ performed lower than did those with ‘college and more.’ In a study by Ranatan et al. (1992), greater muscle strength was also found
among the more highly educated participants when compared to those who were less educated.

In our sample, handgrip strength decreased as the age range increased (Table 5.13). Those findings are confirmed with the distribution of muscle grip strength classification where the percentages of those who had below normal muscle strength increased as the age increased (Table 5.16). Other studies have also shown that muscle mass decreases significantly over time in both men and women (Hughes et al., 2001; Lindle et al., 1997). According to Lindle et al. (1997), this decline is associated with an increased risk of falls (Campbel, Borrie & Spears, 1989), hip fractures (Aniansson, Zetterberg & Hedberg, 1984), and adverse physiological changes such as glucose intolerance (Bloesch et al., 1988), and a loss of bone mineral density (Sinaki et al., 1986). Subsequently, these changes may predispose the elderly to osteoporosis, atherosclerosis, diabetes, and functional limitations in activities of daily living (Lindle et al., 1997; Hughes et al., 2001).

Females (as expected) had lower averages for handgrip strength. Other studies have had similar results, with men having a higher strength on average than women in all muscle groups (Hughes et al., 2001; Wang et al., 2017). For race, ‘NH Black’ had the highest mean, while ‘Mexican Americans’ had the lowest. A study conducted by NCHS also showed that Non-Hispanic Asian and Hispanics had a higher prevalence of reduced muscle strength than Non-Hispanic White and Black individuals. (Looker & Wang, 2015). Other studies have shown that black persons have stronger bones and have greater
bone density which could explain the higher averages in muscle strength for this population (Jorgetti, dos Reis & Ott, 2014; Rantanen et al., 1998).

Those with normal (fair and above) self-rated health, not IADL impaired, and physically active had higher averages for grip strength. Rantanen and coworkers (2015) demonstrated that maintaining or increasing activity levels prevented or attenuated strength declines with age recall. Therefore, “physical activity and lifestyle habits practiced over a lifetime can have a substantial impact on self-rated health and muscle strength” (Ratanen et al., 2015). The relationship with physical activity might also explain why the sample had a decrease in muscle strength with aging; those aged 75-80 had the highest percentages for inactivity and, in turn, the lowest averages for handgrip strength whereas those 60-64 had the highest rates for physical activity and grip strength.

Moreover, it is possible that muscle weakness (reflected in lower grip strength) “leads to decreased function, diminished physical activity, and sometimes immobility, consequently leading to secondary muscular disuse atrophy” (Hirsiger et al., 2015). According to Hughes and colleagues (2001), decreased muscle strength is likely both the result of aging, selective loss of type-2 muscle fibers, or increased levels of pro-inflammatory cytokines. However, it is also possible that "age-related neurological changes, the hormonal and metabolic milieu, pro-inflammatory cytokines, and perhaps fat infiltration—lipotoxicity— may contribute to progressive muscle weakness displayed in older adults" (Schaap et al., 2006). Because of this, further studies are needed to help explain how these factors may be related to changes in strength with aging.
Statistical analysis also showed that those with normal or obese BMI had higher estimates for average handgrip strength than underweight individuals. There are several reasons why muscle strength might be affected by obesity. Obese subjects have greater muscle mass, which, according to Norman et al. (2010), is a significant determinant of muscle strength. Also, research has proposed a "specific training effect induced by bearing and supporting higher weight that can strengthen the muscles of obese subjects" (Norman et al., 2010). A study by Vandewalle et al. (2013) showed that obese adolescents have larger and stronger bones at both the forearm and lower legs and that this effect was related to the greater mechanical loading resulting from a higher muscle mass and strength. On the contrary, other studies have proposed that obese adults have a higher rate of inflammation – where fat deposits can act as endocrine organ secreting various pro-inflammatory cytokines – when compared to their normal weight counterparts (Schrager et al., 2007; Tomlinson et al., 2014) and that inflammation is what is responsible for the relatively low strength in older obese adults (Tomlinson et al., 2016).

One of the most important findings of this study was the association between the sense of smell and muscle strength/average handgrip strength. Low handgrip strength and or ‘below normal’ muscle strength was a significantly associated with an increased risk in developing a smell disorder (not being able to identify the individual scents, thus a low scent total score, or the presence of smell alteration and impairment). A possible explanation for this relationship is association between muscle strength and cognitive function (Firth et al., 2018; Rogers, & Jarrot, 2008; Alfaro-Acha et al., 2006;
Goodpaster et al., 2006; Raji et al., 2005); olfactory function has, in turn, also been shown to be related to cognitive function (Hüttenbrink et al., 2013; Marin et al., 2018; Özdener & Rawson, 2004). Moreover, it is also important to remember that aging itself has been shown to correlate with increases in incidences of frailty such as cognitive decline, sarcopenia, and inflammation, even in the absence of infection, stress, or trauma (Canon & Crimmins, 2011).

Nourhashémi and colleagues (2002) found that low muscle mass in women is associated with low cognitive functioning. A study by Yang et al. (2018), found that stronger handgrip strength was associated with better performances on cognitive tests among women cancer survivors aged 60 years and older. Meanwhile, Christensen and colleagues (1999) reported that "weaker handgrip strength was associated with greater variability in memory change in a sample of 426 elderly community dwellers over 3.5 years" (Raji et al., 2005). A study by Salthouse and colleagues (1998) demonstrated that slow reaction time was associated with reduced cognitive function. A more recent study by Rosano et al. (2005) also confirmed this association; the researchers found a significant correlation between poorer physical performance in gait speed, balance, and lower extremity muscle strength with poor performance in cognitive function in 2893 older adults.

One possible explanation for the relationship between the handgrip and cognitive function is that reduced muscle strength may be an early marker of a "generalized decrease in nervous system processing that is reflected in cognitive function" (Alfaro-Acha et al., 2006). This relationship suggests the presence of a
common mechanism shared by cognitive decline and muscle loss with age (Schaap et al., 2006). However, further research is needed to elucidate this relationship. Another explanation for the association between low muscle strength and reduced cognitive functioning is the presence of some shared pathogenic factors like high oxidative stress, elevated inflammatory markers, and low sex steroid levels that might contribute to both muscle loss and cognitive decline in older adults (Alfar-Ocha et al., 2006; Yang et al., 2018).

Olfactory dysfunction may be an early indicator of neurodegenerative disorders, especially in Parkinson’s disease and Alzheimer’s disease (Seo, Jeon & Hummel, 2009; Ruan et al., 2012; Alves, Petrosyan & Magalhães, 2014; Zou et al., 2016; Doets & Kremer 2016). The pathology of smell loss and neurodegenerative disorders is centered in the olfactory bulb and mucosa (Alves et al., 2014), and anterior olfactory nucleus (Devere, 2012). Other studies have linked Lewy bodies (LBs); Lewy neuritis (LNs) and synucleinopathy in the olfactory bulb (OB) tract and cortex; increase of dopaminergic neurons in the OB; and aggregation of neurofibrillary tangles and senile plaques in the OB and brain to the pathology as well (Huisman et al., 2004; Duda, 2010; Yang et al., 2012). Researchers have also proposed that a “higher density of entorhinal cortex and hippocampal neurofibrillary tangles correlate with more significant deficits of odor identification, which is responsible for the hippocampal dysfunction in Alzheimer’s disease hyposmia: (Bohnen et al., 2010, Wilson et al., 2007). However, the pathophysiology of smell dysfunction in neurodegenerative disorders remains poorly understood (Canon & Crimmins, 2011).
Moreover, we can assume that our sample had cognitive deficits because the subjects who presented IADL impairments were more likely to be smell impaired.

Research has also provided evidence that deficits in IADL may be present in mild cognitive impairment (MCI) (Jekel et al., 2015; Kiosses & Alexopoulos, 2005).

Additionally, previous studies have shown that cognitive deficits such as task-sequencing impairment (apraxia), language difficulties (aphasia), and poor memory or neurodegenerative disorders, such as dementia and Alzheimer’s and Parkinson’s disease, may directly interfere with bathing, grooming, and other vital or similar IADL activities (Holson 2008; Teng et al., 2010; Gold, 2012). Furthermore, IADL impairment had a significant relationship with muscle strength in our sample. Therefore, our findings might point to an inherent connection between cognitive function, muscle strength, and smell. However, to confirm the said relationship, we would need to look at NHANES variables related to the cognitive function of the sample.

Another link that might explain the relationship between muscle strength and smell is protein intake. Winkler et al. (1999) reported that "depletion or inadequate intake of protein is seen as a decrease of skeletal muscle mass which may also be involved in depressed immune function and decreased muscle strength in older adults."

Because of this, the authors recommend that “patients older than 55 years of age should ingest 1.00 to 1.25 grams (g) of high-quality protein per kilogram of their weight daily, as opposed to the 0.8 g recommended for the general population.” More recent studies (Isanejad et al., 2016; Nicolaas et al., 2014; Devries & Phillips, 2015) have shown
that higher-protein diets are associated with muscle mass gain, optimal muscle function, and attenuation of natural loss of muscle mass that accompanies aging.

On the other hand, literature has established a relationship between protein (and caloric intake) and smell function (Gopinath et al., 2016). For instance, a study by Doets and Kremer (2003) reported on Korean women, where participants with the severest degree of olfactory impairment had a lower intakes of energy, protein, fat, carbohydrate, calcium, and iron than those who were less impaired (Kim, Hur, Cho, & Lee, 2003). A study by Rasmussen et al. (2018) found that patients with diabetes and smell impairment consumed less daily food (kcal) and carbohydrate compared to patients with diabetes without smell impairment. Therefore, it is possible that subjects with reduced muscle strength also had inadequate intakes of protein (or calories) which in turn could be associated with smell. The link between protein intake, muscle strength, and smell function is essential because in the elderly this is a modifiable factor that contributes to the well-being and one that could change some health outcomes (Doets and Kremer, 2003). However, we would need to analyze data on dietary intake to confirm this suspicion.

**Sedentary Hours**

Persons who were older and physically or functionally inactive had higher averages of hours of sedentary activity. One of the contributors to this inactivity could be the decreased mobility associated with aging and retirement (Rantanen et al., 2015). When adults retire, their inactivity and leisure-time physical activity increases (DiPietro, 2001). Drewnowski and Evans (2001), found that older adults had lower energy and
physical functioning than their younger counterparts. Cross-sectional data from the Aerobics Center Longitudinal Study confirmed that older adults spent significantly less energy on exercise than did younger adults. Similarly, in the Zutphen Elderly Study of senior men, the mean time spent on physical activity, other than walking, decreased by 28 minutes/day during the ten years of follow-up (Drewnowski and Evans, 2001; Bijnen et al., 1998). Because “sedentary behavior has been linked as a risk factor for chronic diseases, morbidity, and mortality in aging, investigating it is crucial” (DiPietro, 2001).

Our analysis also revealed that a higher average of sedentary hours was associated with the risk for smell impairment (thus scent test total score), smoke, and smell alteration (and its total score). Overall, those who were impaired had a higher average of sedentary activity than those who did not have an impairment. Similarly, our results revealed that sedentary hours had an association with average muscle grip strength, which in turn is associated with all of the smell variables and rated health. A possible reason for this might be that sedentary people have a lower quality of health. Smell dysfunction is associated with reduced quality of life and major health outcomes such as neurodegeneration and death (Rasmussen et al., 2018; Neuland et al., (2011); Boesveldt et al., (2017); Santos et al., 2004; Stevenson, 2010; Hoffman, Cruickshanks & Davis, 2009).

Moreover, people with poorer health and more sedentary hours tend to take multiple medications; thus, medications side effects could cause loss of smell temporarily or permanently. Some drugs that may alter a person's ability to smell or taste are many antibiotics, antidepressants, blood pressure, and heart medications...
(Schiffman, 2018). However, to make this assumption, we would have to investigate the type and number of drugs taken by our study sample.

**Smell Disorder Assessment Variables**

Our study showed that 32.1% of the sample had either a smell alteration and or smell impairment. The population prevalence of smell alteration, impairment, and dysfunction was 17.5%, 15.4%, and 29.8%, respectively. For those variables, there was a higher number of participants who were male and in the 75-80 age range. Thus the main finding of our study was that the prevalence of a smell disorder (smell impairment and smell alteration) was significantly higher in older males above 75 years of age.

In our study, we observed that increasing age is related to the ability to smell. For instance, results showed that the total scent score was higher in those in the age range 60-64, which means that those in that range were able to identify more smells correctly when compared to those 75-80. Similarly, for smell impairment and smell alteration being older (75-80 range) was associated with the risk for the presence of dysfunction. This finding is consistent with previous findings. For instance, Doty et al. (2012) and Liu et al. (2016) found that the decline in smell function happens after the age of 60. Similarly, studies from Rasmussen et al. (2018) and Rawal et al. (2016) have shown that participants with smell impairment, in general, were older and that the rates increased with age. Moreover, Doets and Kremer (2016) “attributed genetic heterogeneity as a contributory factor to sizeable inter-individual variation in the degree of olfactory decline with increasing age.”
For gender, males had lower scent and alteration scores, which is consistent with the fact that being female lowered the risk for the presence of a smell impairment or alteration. Studies have reported that men are more likely to experience smell loss than women and that men suffer smell loss earlier in life than women (Lui et al., 2016; Rasmussen et al., 2018; Hoffman et al., 2016; Wysocki and Gilbert 1989; Ship and Weiffenbach 1993; Ship et al., 1996; Karpa et al., 2010; Mullol et al., 2012). Some have attributed the gender differences to the occupational or environmentally hazardous exposures that are associated with the workforce (Rawal et al., 2015). Other studies have reported estrogen as the responsible agent for the difference between males and females; estrogen has shown to protect against loss of the sense of smell in postmenopausal women (Fark & Hummel, 2013; Dhong, Chung & Doty, 1999; Deems et al., 1991). On the contrary, some studies have reported minimal gender differences. According to Hoffman et al. (2016), “women may be more likely to notice and report changes in chemosensory problems and pathologies associated with an impairment” which might explain the lack of sex-differences in some studies.

**Individual Scents**

Overall, the majority (>50%) of the sample was able to identify the scents correctly, which is consistent with the findings that the majority did not report a smell alteration or impairment. Similarly, of those who failed to identify a scent, there was a higher proportion in the 75-80 range and males, as mentioned previously.

The grape scent was identified incorrectly by the most people (39.0%). Other studies have reported similar findings. For instance, a study by Liu et al. (2016) stated
that grape was the scent with the most incorrect answers – 30.4% of their participants were not able to identify it correctly. A possible explanation for its high percentages might be because grape is a common artificial flavor in a lot of the food products that contain it (U.S National Library of Medicine (2005); Zellner, 2013). Additionally, grape may not be as identifiable or unique or potent as other scents (i.e., chocolate, which had the highest percentage for correct identification); therefore, some people might not be able to recognize it as easily. On the other hand, factors associated with an increased risk for not being able to identify grape (as well as gas) were age – as expected because smell diminishes with age (Hoffman et al., 2016; Lui et al., 2016) –, and the presence of a smell alteration.

Smoke was the only scent out of the three analyzed that was significantly associated with income and education. Results showed that a higher income was related to lower the odds of failing to identify the smell. Lui et al. (2016) suggested that access to healthcare, occupation, and overall quality of life can explain the link between low socioeconomic status and a higher prevalence of smell disorder. Moreover, a lower education level was associated with increased odds of failing to identify smoke and with the presence of smell impairment. Consistent with our findings, a study by Hoffman et al. (2016) also reported a lower educational level as a risk factor of smell impairment, which also helped explain some of the racial/ethnic differences between their sample of non-Hispanic whites and the Hispanics of their study. Similarly, the authors mentioned that low-income status has also been, in turn, associated with poorer educational level in a Beaver Dam Offspring study (Schubert et al., 2012).
Furthermore, a possible explanation as to why the scent of smoke was the only smell associated with lower income and education could be because, typically, industrial or “blue collar” jobs have more significant exposure to environmental toxins that could damage the sense of smell (Sorensen et al., 2004). Studies have also reported airborne pollution and toxic odors in the workplace as factors that can permanently damage the sense of smell (Mann, 2002; Hoffman et al., 2016).

Lastly, the study sample’s prevalence for gas and smoke scent impairment was 15% and 17.2% respectively, which is much lower than in other studies – our study sample is also smaller than those in other similar reports (Hoffman et al., 2016) due to the exclusion criteria of our research. Investigating smoke and gas scent allows for increased awareness, safety, and reduction of the health risk of patients, for example, leading to fewer accidents due to the inability to smell smoke, natural gas or less nutritional effects.

**Scent Test Total Score/Smell Impairment**

The majority of our study population had a score above five for the scent test, which is consistent with the fact that the majority of the people were able to identify the individual scents and were classified as not having a smell impairment. ‘Mexican American’ participants had higher scent test scores when compared to ‘Other Hispanic’ people. However, it is important to keep in mind that ‘Other Hispanic’ had the least amount of participants from all race levels. Overall, factors that were associated with a decreased scent test total score were lower income, poor self-rated health, below
normal muscle strength, low smell alteration score, and the presence of a smell alteration.

The overall estimated prevalence of smell impairment (which is related to the total scent score) was 15.4% for the general U.S population. This estimate is similar to a study by Lui et al. 2016, where those estimates were also higher among males and those older than 75 years of age. In our study, ‘NH Black’ (race) had the highest proportion of smell impairment (24%). The same study by Lui and colleagues (2016) also demonstrated that certain ethnic groups, such as non-Hispanic Blacks and Mexican Americans, had a higher prevalence of smell impairment than that observed for White Americans. Other studies have demonstrated that older African-Americans and Hispanics had a worse olfactory function. (Lui et al., 2016; Pinto et al., 2015). However, it is important to note that in our sample, none of the specific race had a significant effect (p>0.05), possibly due to low numbers of representation for some racial groups.

Moreover, the presence of a smell alteration was significantly associated with an increased risk of developing a smell impairment. However, the majority of the participants with a smell impairment did not self-report any smell alteration. This means that the individual was not aware of a problem with their smell, but the results from the scent test revealed that they had failed to identify various odors correctly.

Other health factors associated with an increased risk for the presence of smell impairment were low education, IADL impairment, and low self-rated health. Therefore, the presence of smell impairment is significantly associated with the health status of older adults. As mentioned previously, studies have shown that a poor sense of smell
affects the quality of life and the health of patients (Boesveldt et al., 2017). For instance, Boesveldt and colleagues (2017) mentioned that individuals with olfactory dysfunction report: difficulties in cooking, decreased appetite and enjoyment of eating, challenges in maintaining personal hygiene and social relationships or fear of hazardous events and safety. Those findings are in accordance with our study, where older individuals who were IADL impaired, which measured the physical functioning difficulty of everyday activities, had higher odds for the presence of smell impairment. On the other hand, one of the reasons why poor self-rated health might be associated with smell impairment could be that those that consider their health as “poor” might, indeed, have health issues and psychological and physical disorders that affect their smell.

On the other hand, studies have proposed a link between weight and smell dysfunction. Smell dysfunction may affect dietary intake, which, in turn, could cause weight loss and even malnutrition (Correia et al., 2016). However, for our study sample, weight changes, current weight, and or BMI were not significantly ($p>0.05$) associated with the presence of smell impairment. A reason for this finding might be that weight variables were self-reported and depended on participant’s memory and perception. Similarly, none of the smell confounding variables (CSQ200, CSQ204, CSQ240, and CSQ250) were statistically significant ($p>0.05$). A possible explanation for that is that more than 75% of the sample responded ‘No’ to those questions. From those, the variable with the highest percentage (30.7%) of ‘Yes’ was CSQ204 (nasal congestion).
This result is consistent with the fact that nasal congestions are more common and prevalent in the general population (Steward, Fergunson & Fromer, 2010).

Previous studies have shown how the sense of smell plays a significant role in eating behavior and in the stimulation of appetite (Boesveldt & De Graaf 2017). A review by Boesveldt et al. (2017) mentioned a study done by Fifth Sense, a United Kingdom-based charity, for people affected by smell and taste disorders, which showed that “among 496 respondents, 92% reported a reduced appreciation of food and drink” (Philpott and Boak, 2014). Despite this relationship, appetite was not statistically significant (p>0.05) in our study sample. Again, this variable was self-reported; therefore, memory and the participants’ perception of how their appetite has changed might have been underestimated our reports.

Likewise, smoking was not statistically significant (p>0.05) with olfactory impairment in our analysis. According to Lui et al. (2016), studies provide evidence that smoking may exert an adverse effect on smell function, whereas others do not observe such a link. Additionally, a survey by Mullol et al. (2012) found that smoking and exposure to noxious substances were even mild protective factors for smell recognition. However, it is important to note that smoking information was limited for our sample, which also prevents us from making definite conclusions.

**Smell Questionnaire Component**

One advantage of the self-report for smell, compared to the scent test, is that it allowed us to investigate the perceived changes and decreases in the smell, while the single measure of olfactory function by identification did not. For the smell
questionnaire variables (CSQ010, CSQ_change, and CSQ020), over 90% of the study population responded ‘No,’ and those who responded ‘Yes’ were more likely to be male and in the age range of 60-64. The 60-64 might have been the highest range because participants might have had better memory or because those in that age might adjust their answers to reflect the expectations at a given age; younger subjects may have a recent memory of a much better sense of smell and readily notice and report any diminution or impairment (Hoffman et al., 2016). Another reason for the increased ‘yes’ responses in the 60-64 age range, for smell questionnaire variables, is that was the range with the highest number of participants.

Factors associated with an increased risk for the presence of smell alteration (thus with the smell alteration total score) are IALD impairment, current weight, and obese and overweight BMI. Results showed that the current weight’s mean was higher among those with a ‘SA present’ (Table 5.49). Contrary to our findings, some studies have found that daily calorie intake appears to be reduced in people with a smell dysfunction which leads to weight loss (Kong et al., 2016; Mattes et al., 1990). Other studies support a relationship between weight gain and olfactory function. For instance, a survey by Fernandez-Aranda et al. (2016) found that in the extreme weight/eating conditions smell was impaired in obese participants and that ghrelin levels were significantly decreased in obese subjects. They proposed that smell capacity and ghrelin may act as moderators of emotional eating and BMI.
CHAPTER 7

CONCLUSION

Findings from this nationally representative survey suggest that smell declines with age. More longitudinal research studies are needed to confirm this concept. Additionally, separating males and females for our statistical analysis will allow us to draw more definite conclusions and understand gender differences. The increased risk for the decline in smell appears to be in older adults that aged 75-80 and male. Furthermore, a smell disorder was negatively associated with the majority of the health assessment variables. For instance, persons with impaired or altered smell had lower self-rated health, were IADL-impaired, had higher sedentary hours’ averages, physical inactivity, and higher BMI (only for smell alteration).

Contrary to other studies, no associations between smell disorders and smoking and appetite were found. One of the unique findings from this research was that smell function was associated with the average handgrip strength/muscle strength; a higher occurrence of smell impairment was observed in patients with low averages of handgrip strength and below normal muscle strength. Overall, a smell disorder affected the health status negatively in older adults. However, future prospective studies are needed to investigate the causal links between smell impairment and cognitive decline, depression, and dietary intake.

Physiological changes related to aging, such as smell loss, can lead to many health hazards; therefore, it is essential to understand the processes that lead to them and potentially find ways to identify those at greatest risk. Overall, understanding the
relationship between smell distortions and health will allow for early interventions to prevent the multitude of adverse health outcomes and help maintain quality of life throughout the aging process, and reduce the burden on healthcare resources.

**Strengths and Weaknesses**

The strengths of our study are that the data obtained by the examination and questionnaire components have nearly identical test conditions by trained technicians according to standard procedures, and multiple measurements of functional outcomes. Some limitations that apply to our findings are that we used data (primarily the data where we examined risk factors) obtained by interviews and self-reporting, which increased the risk of information bias. Second, the lack of longitudinal data did not exclude the possibility of a survivor effect in this instance. For example, it is possible that men and women with smell impairment or poor muscle strength died before the age of 80 and that individuals older than 75 represented a selectively healthy group of individuals relative to people younger than 75. Lastly, the cross-sectional nature of NHANES does not allow us to draw conclusions regarding temporality or the causal effects driving the relationship between smell and functional outcomes.

**Future Directions**

There was a link between smell and muscle strength that might be explained by the co-morbidities of impaired cognitive function and depression. Studies have linked a depressed mood to a muscle strength decline, particularly in older men with low body weight (Rantanen et al., 2015; Huo et al., 2015) and with a disability in the activities of daily living (Ido et al., 2015; Yang, 2015). This phenomenon is concerning because
depression has been reported in 12 to 20% of free-living older people (Rantanen et al., 2015). Therefore, future research should investigate these factors. NHANES has a mental health-depression screener (DPQ-H) questionnaire (Table 7.1) that would be useful to consider for future studies involving smell. Research using later NHANES data should also evaluate cognitive function and depression.

Table 7.1: Possible variables to be included in future studies from the mental health-depression screener (DPQ-H) questionnaire.

<table>
<thead>
<tr>
<th>Question</th>
<th>Variable label</th>
</tr>
</thead>
<tbody>
<tr>
<td>Have little interest in doing things</td>
<td>DPQ010</td>
</tr>
<tr>
<td>Feeling down, depressed, or hopeless</td>
<td>DPQ020</td>
</tr>
<tr>
<td>Trouble sleeping or sleeping too much</td>
<td>DPQ030</td>
</tr>
<tr>
<td>Feeling tired or having little energy</td>
<td>DPQ040</td>
</tr>
<tr>
<td>Feeling bad about yourself</td>
<td>DPQ060</td>
</tr>
<tr>
<td>Trouble concentrating on things</td>
<td>DPQ070</td>
</tr>
<tr>
<td>Moving or speaking slowly or too fast</td>
<td>DPQ080</td>
</tr>
<tr>
<td>Thought you would be better off dead</td>
<td>DPQ090</td>
</tr>
</tbody>
</table>

Similarly, a list of medications should be analyzed to understand their interactions with smell function and or muscle strength. NHANES provides the prescription medications (RXQ_RX_H) questionnaire, which collects information on dietary supplements, non-prescription antacids, prescription medications, and preventive aspirin use. Dietary intake (specifically protein and calories) and how its relationship with the smell and the health of the older adults was not addressed in our study; studies have shown a relationship with dietary intake and smell (Hoffman et al., 2016). Moreover, it would also be helpful to investigate more extensively smoking habits (include more smoking variables, such as years of smoking) to understand its
effect on smell and the health status and to determine whether or not natural smell changes associated with aging could be aggravated by the use of tobacco.

As the U.S. and global populations live longer, more information will be needed to help those older individuals stay healthy and maintain an acceptable quality of life. Measurement of smell loss could be a tool for choosing when to initiate interventions to counteract loss of appetite and reduced physical activity that lead to frailty.
REFERENCES


and Medical Sciences, 56 Spec No 2(Supplement 2), 89-94. doi:10.1093/gerona/56.suppl_2.89.


126


# Appendix A Original Coding for Variables

Table A.1 Original variable names, coding and meaning from the 2013-2014 NHANES data for older adults 60 years and older

<table>
<thead>
<tr>
<th>Variable</th>
<th>Name</th>
<th>Code</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>SEQN</td>
<td>Respondent Sequence Number</td>
<td></td>
<td>Demographics Data Set (Demo_H.XPT)</td>
</tr>
<tr>
<td>RIAGENDR</td>
<td>Gender</td>
<td>1</td>
<td>Male</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>Female</td>
</tr>
<tr>
<td>RIDAGEYR</td>
<td>Age in years at screening</td>
<td>0-79</td>
<td>Range of Values</td>
</tr>
<tr>
<td></td>
<td></td>
<td>80</td>
<td>80 years of age and over</td>
</tr>
<tr>
<td>RIDRETH1</td>
<td>Race/Hispanic origin</td>
<td>1</td>
<td>Mexican American</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>Other Hispanic</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>Non-Hispanic White</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>Non-Hispanic Black</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5</td>
<td>Other Race - Including Multi-Racial</td>
</tr>
<tr>
<td>DMDEDUC2</td>
<td>Education level - Adults 20+</td>
<td>1</td>
<td>Less than 9th grade</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>9-11th grade (Includes 12th grade with no diploma)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>High school graduate/GED or equivalent</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>Some college or AA degree</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5</td>
<td>College graduate or above</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7</td>
<td>Refused</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9</td>
<td>Don't Know</td>
</tr>
<tr>
<td></td>
<td></td>
<td>.</td>
<td>Missing</td>
</tr>
<tr>
<td>INDFMPIR</td>
<td>Ratio of family income to poverty</td>
<td>0-4.99</td>
<td>Range of Values</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5</td>
<td>Value greater than or equal to 5.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>.</td>
<td>Missing</td>
</tr>
<tr>
<td>CSXEXSTS</td>
<td>Overall Taste &amp; Smell Exam Status</td>
<td>1</td>
<td>Complete</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>Partial</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>Not done</td>
</tr>
<tr>
<td></td>
<td></td>
<td>.</td>
<td>Missing</td>
</tr>
<tr>
<td>CSXCHOOD</td>
<td>Smell Test: Chocolate Scent</td>
<td>1</td>
<td>Lemon</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>Chocolate</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>Smoke</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>Black pepper</td>
</tr>
<tr>
<td>Table A.1 Continued</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---------------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>CSXSBO</strong>D</td>
<td>Smell Test: Strawberry Scent</td>
<td>.</td>
<td>Missing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>Strawberry</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>Garlic</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>Leather</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>Gasoline</td>
</tr>
<tr>
<td><strong>CSXSMK</strong>OD</td>
<td>Smell Test: Smoke Scent</td>
<td>.</td>
<td>Missing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>Garlic</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>Grass</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>Smoke</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>Peach</td>
</tr>
<tr>
<td><strong>CSXLEAO</strong>D</td>
<td>Smell Test: Leather Scent</td>
<td>.</td>
<td>Missing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>Mint</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>Flower</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>Leather</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>Apple</td>
</tr>
<tr>
<td><strong>CSXSOAO</strong>D</td>
<td>Smell Test: Soap Scent</td>
<td>.</td>
<td>Missing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>Soap</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>Black Pepper</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>Leather</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>Peanut</td>
</tr>
<tr>
<td><strong>CSXGROA</strong>D</td>
<td>Smell Test: Grape Scent</td>
<td>.</td>
<td>Missing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>Gasoline</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>Grape</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>Rose</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>Peanut</td>
</tr>
<tr>
<td><strong>CSXOAO</strong>D</td>
<td>Smell Test: Onion Scent</td>
<td>.</td>
<td>Missing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>Chocolate</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>Strawberry</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>Onion</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>Fruit Punch</td>
</tr>
<tr>
<td><strong>CSXNGSO</strong>D</td>
<td>Smell Test: Natural Gas Scent</td>
<td>.</td>
<td>Missing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>Orange</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>Cinnamon</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>Cola</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>Natural Gas</td>
</tr>
</tbody>
</table>

**Muscle Strength-Grip Test Data Set (MGX_H.xpt)**

<p>| <strong>MGATHAND</strong> | Begin the test with this hand. | 1 | Right |
|             |                                 | 2 | Left  |</p>
<table>
<thead>
<tr>
<th>MGXH1T1</th>
<th>Grip strength (kg), hand 1, test 1</th>
<th>Range of Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>MGXH2T1</td>
<td>Grip strength (kg), hand 2, test 1</td>
<td>Range of Values</td>
</tr>
<tr>
<td>MGXH1T2</td>
<td>Grip strength (kg), hand 1, test 2</td>
<td>Range of Values</td>
</tr>
<tr>
<td>MGXH1T2</td>
<td>Grip strength (kg), hand 2, test 2</td>
<td>Range of Values</td>
</tr>
<tr>
<td>MGXH2T2</td>
<td>Grip strength (kg), hand 2, test 2</td>
<td>Range of Values</td>
</tr>
<tr>
<td>MGXH1T3</td>
<td>Grip strength (kg), hand 1, test 3</td>
<td>Range of Values</td>
</tr>
<tr>
<td>MGXH2T3</td>
<td>Grip strength (kg), hand 2, test 3</td>
<td>Range of Values</td>
</tr>
<tr>
<td>MGDEXSTS</td>
<td>Grip test status</td>
<td>n/a</td>
</tr>
<tr>
<td>MGD050</td>
<td>Ever had surgery on hands or wrists</td>
<td>n/a</td>
</tr>
<tr>
<td>MGDCGSZ</td>
<td>Combined grip strength (kg)</td>
<td>n/a</td>
</tr>
</tbody>
</table>

**Weight History Data Set (WHQ_H.xpt)**

<table>
<thead>
<tr>
<th>WHD010</th>
<th>Current self-reported height (inches)</th>
<th>48 to 81</th>
<th>Range of Values</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>7777</td>
<td>Refused</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9999</td>
<td>Don't know</td>
</tr>
<tr>
<td></td>
<td></td>
<td>.</td>
<td>Missing</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>WHD020</th>
<th>Current self-reported weight (pounds)</th>
<th>75 to 493</th>
<th>Range of Values</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>7777</td>
<td>Refused</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9999</td>
<td>Don't know</td>
</tr>
<tr>
<td></td>
<td></td>
<td>.</td>
<td>Missing</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>WHD050</th>
<th>Self-reported weight - 1 yr. ago (pounds)</th>
<th>75 to 559</th>
<th>Range of Values</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>7777</td>
<td>Refused</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9999</td>
<td>Don't know</td>
</tr>
<tr>
<td></td>
<td></td>
<td>.</td>
<td>Missing</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>WHD110</th>
<th>Self-reported weight-10 yrs. ago (pounds)</th>
<th>75 to 600</th>
<th>Range of Values</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>7777</td>
<td>Refused</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9999</td>
<td>Don't know</td>
</tr>
<tr>
<td></td>
<td></td>
<td>.</td>
<td>Missing</td>
</tr>
</tbody>
</table>

**Smoking Data Set (SMQ_H.xpt)**
<table>
<thead>
<tr>
<th>SMQ020</th>
<th>Smoked at least 100 cigarettes in life</th>
<th>1</th>
<th>Yes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7</td>
<td>Refused</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9</td>
<td>Don't know</td>
</tr>
<tr>
<td></td>
<td></td>
<td>.</td>
<td>Missing</td>
</tr>
<tr>
<td>SMD030</td>
<td>Age started smoking cigarettes regularly</td>
<td>7 to 64</td>
<td>Range of Values</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0</td>
<td>Never smoked cigarettes regularly</td>
</tr>
<tr>
<td></td>
<td></td>
<td>80</td>
<td>80 years or older</td>
</tr>
<tr>
<td></td>
<td></td>
<td>777</td>
<td>Refused</td>
</tr>
<tr>
<td></td>
<td></td>
<td>999</td>
<td>Don't know</td>
</tr>
<tr>
<td></td>
<td></td>
<td>.</td>
<td>Missing</td>
</tr>
<tr>
<td>SMQ040</td>
<td>Do you now smoke cigarettes</td>
<td>1</td>
<td>Every day</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>Some days</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>Not at all</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7</td>
<td>Refused</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9</td>
<td>Don't know</td>
</tr>
<tr>
<td></td>
<td></td>
<td>.</td>
<td>Missing</td>
</tr>
<tr>
<td>SMD055</td>
<td>Age last smoked cigarettes regularly</td>
<td>14 to 79</td>
<td>Range of Values</td>
</tr>
<tr>
<td></td>
<td></td>
<td>80</td>
<td>80 years or older</td>
</tr>
<tr>
<td></td>
<td></td>
<td>777</td>
<td>Refused</td>
</tr>
<tr>
<td></td>
<td></td>
<td>999</td>
<td>Don't know</td>
</tr>
<tr>
<td></td>
<td></td>
<td>.</td>
<td>Missing</td>
</tr>
<tr>
<td>CSQ010</td>
<td>Had problem with smell past 12 months?</td>
<td>1</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7</td>
<td>Refused</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9</td>
<td>Don't know</td>
</tr>
<tr>
<td></td>
<td></td>
<td>.</td>
<td>Missing</td>
</tr>
<tr>
<td>CSQ020</td>
<td>Had change ability to smell since age 25</td>
<td>1</td>
<td>Better Now</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>Worse Now</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>No Change</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7</td>
<td>Refused</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9</td>
<td>Don't know</td>
</tr>
<tr>
<td></td>
<td></td>
<td>.</td>
<td>Missing</td>
</tr>
<tr>
<td>CSQ040</td>
<td>Had phantom odor?</td>
<td>1</td>
<td>Yes</td>
</tr>
<tr>
<td>--------</td>
<td>-------------------</td>
<td>---</td>
<td>------</td>
</tr>
<tr>
<td>CSQ200</td>
<td>Persistent cold/flu last 12 months?</td>
<td>1</td>
<td>Yes</td>
</tr>
<tr>
<td>CSQ204</td>
<td>Frequent nasal congestion in past 12 months</td>
<td>1</td>
<td>Yes</td>
</tr>
<tr>
<td>CSQ240</td>
<td>Head Injury/Loss of consciousness</td>
<td>1</td>
<td>Yes</td>
</tr>
<tr>
<td>CSQ250</td>
<td>Broke Nose/Serious Injury to Face/Skull</td>
<td>1</td>
<td>Yes</td>
</tr>
<tr>
<td>HUQ010</td>
<td>General health condition (Self Health)</td>
<td>1</td>
<td>Excellent/VG/Good</td>
</tr>
<tr>
<td>DPQ050</td>
<td>Poor appetite or overeating</td>
<td>0</td>
<td>Not at all</td>
</tr>
</tbody>
</table>
Table A.1 Continued

<table>
<thead>
<tr>
<th>Physical Activity (PAQ_H)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>PAQ605 Vigorous work activity</td>
<td>1</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>Refused</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>Don't know</td>
</tr>
<tr>
<td>PAQ620 Moderate work activity</td>
<td>.</td>
<td>Missing</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>7777</td>
<td>Refused</td>
</tr>
<tr>
<td></td>
<td>9999</td>
<td>Don't know</td>
</tr>
<tr>
<td>PAD680 Minutes sedentary activity</td>
<td>.</td>
<td>Missing</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>7777</td>
<td>Refused</td>
</tr>
<tr>
<td></td>
<td>9999</td>
<td>Don't know</td>
</tr>
<tr>
<td>PAQ635 Walk or bicycle</td>
<td>.</td>
<td>Missing</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>Refused</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>Don't know</td>
</tr>
<tr>
<td>PAQ605 Moderate recreational activity</td>
<td>.</td>
<td>Missing</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>Refused</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>Don't know</td>
</tr>
<tr>
<td>PAQ650 Vigorous recreational activity</td>
<td>.</td>
<td>Missing</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>Refused</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>Don't know</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Physical Functioning (PFQ_H)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>PFQ061F House chore difficulty</td>
<td>1</td>
<td>No difficulty</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Some difficulty</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Much difficulty</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Unable to do</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>Do not do this activity</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>Refused</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>Don't know</td>
</tr>
<tr>
<td></td>
<td>.</td>
<td>Missing</td>
</tr>
<tr>
<td>Table A.1 Continued</td>
<td></td>
<td></td>
</tr>
<tr>
<td>---------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>PFQ061A</strong></td>
<td>Managing money difficulty</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>No difficulty</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Some difficulty</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Much difficulty</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Unable to do</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Do not do this activity</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Refused</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Don't know</td>
<td></td>
</tr>
<tr>
<td>.</td>
<td>Missing</td>
<td></td>
</tr>
<tr>
<td><strong>PFQ061G</strong></td>
<td>Preparing meals difficulty</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>No difficulty</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Some difficulty</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Much difficulty</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Unable to do</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Do not do this activity</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Refused</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Don't know</td>
<td></td>
</tr>
<tr>
<td>.</td>
<td>Missing</td>
<td></td>
</tr>
<tr>
<td><strong>PFQ061J</strong></td>
<td>Getting in and out of bed difficulty</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>No difficulty</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Some difficulty</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Much difficulty</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Unable to do</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Do not do this activity</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Refused</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Don't know</td>
<td></td>
</tr>
<tr>
<td>.</td>
<td>Missing</td>
<td></td>
</tr>
<tr>
<td><strong>PFQ061L</strong></td>
<td>Dressing yourself difficulty</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>No difficulty</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Some difficulty</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Much difficulty</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Unable to do</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Do not do this activity</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Refused</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Don't know</td>
<td></td>
</tr>
<tr>
<td>.</td>
<td>Missing</td>
<td></td>
</tr>
</tbody>
</table>
## Appendix B Missing Values

Table B.1 Frequency and percentages of missing values of the NHANES 2013-2014 variables of interest

<table>
<thead>
<tr>
<th>Variable Label</th>
<th>Name</th>
<th>Missing value</th>
<th>% Missing</th>
<th>Included *(X)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demographics</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>Gender</td>
<td>0</td>
<td>0%</td>
<td>X</td>
</tr>
<tr>
<td>Age Categories</td>
<td>Agecat</td>
<td>0</td>
<td>0%</td>
<td>X</td>
</tr>
<tr>
<td>Race</td>
<td>RIDRETH1</td>
<td>0</td>
<td>0%</td>
<td>X</td>
</tr>
<tr>
<td>Education/ Level of Education</td>
<td>Educ</td>
<td>1</td>
<td>0%</td>
<td>X</td>
</tr>
<tr>
<td>Income/ 'Income to poverty ratio'</td>
<td>Income</td>
<td>98</td>
<td>7.6%</td>
<td>X</td>
</tr>
<tr>
<td>Cohabitation Status</td>
<td>marital_status</td>
<td>1</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td>Smell Examination Component</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chocolate Scent Smell Test</td>
<td>choco_ST</td>
<td>0</td>
<td>0%</td>
<td>X</td>
</tr>
<tr>
<td>Strawberry Scent Smell Test</td>
<td>straw_ST</td>
<td>0</td>
<td>0%</td>
<td>X</td>
</tr>
<tr>
<td>Smoke Scent Smell Test</td>
<td>smoke_ST</td>
<td>0</td>
<td>0%</td>
<td>X</td>
</tr>
<tr>
<td>Leather Scent Smell Test</td>
<td>leather_ST</td>
<td>0</td>
<td>0%</td>
<td>X</td>
</tr>
<tr>
<td>Soap Scent Smell Test</td>
<td>soap_ST</td>
<td>0</td>
<td>0%</td>
<td>X</td>
</tr>
<tr>
<td>Grape Scent Smell Test</td>
<td>grape_ST</td>
<td>0</td>
<td>0%</td>
<td>X</td>
</tr>
<tr>
<td>Onion Scent Smell Test</td>
<td>onion_ST</td>
<td>0</td>
<td>0%</td>
<td>X</td>
</tr>
<tr>
<td>Natural Gas Scent Smell Test</td>
<td>gas_ST</td>
<td>0</td>
<td>0%</td>
<td>X</td>
</tr>
<tr>
<td>Presence of Smell Impairment</td>
<td>smell_imp</td>
<td>0</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td>Grip Test</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Dominant Hand</td>
<td>MGD130</td>
<td>0</td>
<td>0%</td>
<td>X</td>
</tr>
<tr>
<td>Ever had surgery on hands or wrists</td>
<td>MGD050</td>
<td>1</td>
<td>0%</td>
<td>X</td>
</tr>
<tr>
<td>Muscle Strength Test Categories- Normal or Below</td>
<td>musclest_cat2</td>
<td>0</td>
<td>0%</td>
<td>X</td>
</tr>
<tr>
<td>Dominant Hand Grip Test</td>
<td>dominanhand_gt</td>
<td>0</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td>Weight History</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current self-reported height (m)</td>
<td>Height</td>
<td>14</td>
<td>1.1%</td>
<td>X</td>
</tr>
<tr>
<td>BMI Categories</td>
<td>BMICat</td>
<td>14</td>
<td>1.1%</td>
<td>X</td>
</tr>
<tr>
<td>Weight 1 yr. ago (kg)</td>
<td>weight1_kg</td>
<td>20</td>
<td>1.60%</td>
<td>X</td>
</tr>
<tr>
<td>Category</td>
<td>Code</td>
<td>Value</td>
<td>Percentage</td>
<td>Status</td>
</tr>
<tr>
<td>-----------------------------------------------</td>
<td>---------------</td>
<td>-------</td>
<td>------------</td>
<td>--------</td>
</tr>
<tr>
<td>Weight 10 yrs. ago (kg)</td>
<td>weight10_kg</td>
<td>33</td>
<td>3%</td>
<td>X</td>
</tr>
<tr>
<td>Categories for Weight Change over the past year</td>
<td>WC1y_cat</td>
<td>52</td>
<td>4%</td>
<td>X</td>
</tr>
<tr>
<td>Categories for Weight Change over the past 10 years</td>
<td>WC1y0_cat</td>
<td>61</td>
<td>4.7%</td>
<td>X</td>
</tr>
<tr>
<td>Current weight (kg)</td>
<td>currentweight</td>
<td>14</td>
<td>1%</td>
<td></td>
</tr>
<tr>
<td>Smell Quest.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Presence of Smell Impairment and or Smell Alteration</td>
<td>smell_dys</td>
<td>0</td>
<td>0%</td>
<td>X</td>
</tr>
<tr>
<td>Had change ability to smell since age 25</td>
<td>CSQ020</td>
<td>4</td>
<td>0%</td>
<td>X</td>
</tr>
<tr>
<td>Had phantom odor?</td>
<td>CSQ040</td>
<td>0</td>
<td>0%</td>
<td>X</td>
</tr>
<tr>
<td>Ability to smell since age 25</td>
<td>CSQ_change</td>
<td>4</td>
<td>0%</td>
<td>X</td>
</tr>
<tr>
<td>Self-Reported Smell Alteration</td>
<td>smell_alt</td>
<td>4</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td>When noticed change in ability to smell</td>
<td>CSQ060</td>
<td>1047</td>
<td>81.5%</td>
<td></td>
</tr>
<tr>
<td>Frequency of problem w/ ability to smell</td>
<td>CSQ070</td>
<td>1038</td>
<td>81%</td>
<td></td>
</tr>
<tr>
<td>Discussed T/S problem with Dr.?</td>
<td>CSQ160</td>
<td>749</td>
<td>58%</td>
<td>X</td>
</tr>
<tr>
<td>Persistent cold/flu last 12 months?</td>
<td>CSQ200</td>
<td>5</td>
<td>0%</td>
<td>X</td>
</tr>
<tr>
<td>Frequent nasal congestion in past 12 months?</td>
<td>CSQ204</td>
<td>3</td>
<td>0%</td>
<td>X</td>
</tr>
<tr>
<td>Head Injury/Loss of consciousness</td>
<td>CSQ240</td>
<td>3</td>
<td>0%</td>
<td>X</td>
</tr>
<tr>
<td>Broke Nose/Serious Injury to Face/Skull</td>
<td>CSQ250</td>
<td>3</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td>Hospital Utilization Quest.</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Self-Rated Health Condition</td>
<td>rated_health</td>
<td>0</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td>Depression Quest.</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Poor Appetite or Overeating</td>
<td>appetite</td>
<td>30</td>
<td>2.30%</td>
<td></td>
</tr>
<tr>
<td>Physical Functioning</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Presence of Mobility Function Limitations</td>
<td>mobility_function</td>
<td>225</td>
<td>17.50%</td>
<td>X</td>
</tr>
<tr>
<td>Presence of IADL Impairment</td>
<td>IADL_imp</td>
<td>1</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td>Activity Description</td>
<td>Code</td>
<td>Value</td>
<td>Percentage</td>
<td>X</td>
</tr>
<tr>
<td>----------------------</td>
<td>---------</td>
<td>-------</td>
<td>------------</td>
<td>---</td>
</tr>
<tr>
<td>Walking up ten steps difficulty</td>
<td>PFQ061C</td>
<td>225</td>
<td>17.50%</td>
<td>X</td>
</tr>
<tr>
<td>Difficulty stooping, crouching or kneeling</td>
<td>PFQ061D</td>
<td>1</td>
<td>0%</td>
<td>X</td>
</tr>
<tr>
<td>Standing up from armless chair difficulty</td>
<td>PFQ061I</td>
<td>1</td>
<td>0%</td>
<td>X</td>
</tr>
<tr>
<td>Difficulty carrying something as heavy as 10 pounds</td>
<td>PFQ061E</td>
<td>1</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td>Difficulty walking a quarter mile</td>
<td>PFQ061B</td>
<td>223</td>
<td>17%</td>
<td>X</td>
</tr>
<tr>
<td>House chore difficulty</td>
<td>PFQ061F</td>
<td>1</td>
<td>0%</td>
<td>X</td>
</tr>
<tr>
<td>Managing money difficulty</td>
<td>PFQ061A</td>
<td>1</td>
<td>0%</td>
<td>X</td>
</tr>
<tr>
<td>Preparing meals difficulty</td>
<td>PFQ061G</td>
<td>1</td>
<td>0%</td>
<td>X</td>
</tr>
<tr>
<td>Getting in and out of bed difficulty</td>
<td>PFQ061J</td>
<td>1</td>
<td>0%</td>
<td>X</td>
</tr>
<tr>
<td>Dressing yourself difficulty</td>
<td>PFQ061L</td>
<td>1</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td>Physical Activity</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Is the participant active at work?</td>
<td>work_active</td>
<td>1</td>
<td>0%</td>
<td>X</td>
</tr>
<tr>
<td>Is the participant recreationally active?</td>
<td>recre_active</td>
<td>0</td>
<td>0%</td>
<td>X</td>
</tr>
<tr>
<td>Is the participant recreationally and or work active?</td>
<td>person_active</td>
<td>1</td>
<td>0%</td>
<td>X</td>
</tr>
<tr>
<td>Minutes sedentary activity</td>
<td>PAD680</td>
<td>7</td>
<td>0%</td>
<td>X</td>
</tr>
<tr>
<td>Vigorous work activity</td>
<td>PAQ605</td>
<td>0</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td>Number of days vigorous work</td>
<td>PAQ610</td>
<td>1139</td>
<td>88.6%</td>
<td></td>
</tr>
<tr>
<td>Minutes vigorous-intensity work</td>
<td>PAD615</td>
<td>1139</td>
<td>88.6%</td>
<td>X</td>
</tr>
<tr>
<td>Moderate work activity</td>
<td>PAQ620</td>
<td>0</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td>Number of days moderate work</td>
<td>PAQ625</td>
<td>929</td>
<td>72%</td>
<td></td>
</tr>
<tr>
<td>Minutes moderate-intensity work</td>
<td>PAD630</td>
<td>930</td>
<td>72%</td>
<td></td>
</tr>
<tr>
<td>Minutes walking/biking for transportation</td>
<td>PAD645</td>
<td>1046</td>
<td>81%</td>
<td></td>
</tr>
<tr>
<td>Minutes vigorous recreational activities</td>
<td>PAD660</td>
<td>1155</td>
<td>90%</td>
<td></td>
</tr>
<tr>
<td>Number of days walk or bicycle</td>
<td>PAQ640</td>
<td>1045</td>
<td>81%</td>
<td></td>
</tr>
</tbody>
</table>
Table B.1 Continued

<table>
<thead>
<tr>
<th>Activity Type</th>
<th>Code</th>
<th>N</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minutes moderate recreational activities</td>
<td>PAD675</td>
<td>739</td>
<td>58%</td>
</tr>
<tr>
<td>Days vigorous recreational activities</td>
<td>PAQ655</td>
<td>739</td>
<td>58%</td>
</tr>
<tr>
<td>Days moderate recreational activities</td>
<td>PAQ670</td>
<td>1155</td>
<td>90%</td>
</tr>
<tr>
<td>Walk or bicycle</td>
<td>PAQ635</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Vigorous recreational activity</td>
<td>PAQ650</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Moderate recreational activity</td>
<td>PAQ665</td>
<td>0</td>
<td>0%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Smoking Variables</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Smoked Years (calculated from SMQ040, SMQ020, SMD030, SMD055)</td>
<td>smoked_years</td>
<td>182</td>
<td>14.2%</td>
</tr>
<tr>
<td>Smoked at least 100 cigarettes in life</td>
<td>SMQ020</td>
<td>1</td>
<td>0%</td>
</tr>
<tr>
<td>Age started smoking cigarettes regularly</td>
<td>SMD030</td>
<td>619</td>
<td>48%</td>
</tr>
<tr>
<td>Do you now smoke cigarettes</td>
<td>SMQ040</td>
<td>619</td>
<td>48%</td>
</tr>
<tr>
<td>Age last smoked cigarettes regularly</td>
<td>SMD055</td>
<td>797</td>
<td>62%</td>
</tr>
</tbody>
</table>

*Included in the study sample and analysis.
APPENDIX C: Distributions

Figure C.1 Shows the Distribution (%) of the current weight in kg.

![Distribution of current weight](image)

Figure C.2 Shows the Distribution (%) of the average dominant hand grip strength in kg.

![Distribution of dominant hand grip](image)
Figure C.3 Shows the Distribution (%) of the hours of sedentary activity
APPENDIX D: Unadjusted and Adjusted Means

Table D.1 Unadjusted and adjusted means for continuous variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Unadjusted Mean</th>
<th>Adjusted Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current Weight</td>
<td>80.7</td>
<td>81.3</td>
</tr>
<tr>
<td>Average Hand Grip Strength</td>
<td>31.3</td>
<td>30.8</td>
</tr>
<tr>
<td>Sedentary Hours</td>
<td>7.15</td>
<td>7.18</td>
</tr>
</tbody>
</table>

Table D.2 Gender and age unadjusted and adjusted means for current weight

<table>
<thead>
<tr>
<th>Variable</th>
<th>Unadjusted Mean</th>
<th>Adjusted Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>Unadjusted Mean</td>
<td>Adjusted Mean</td>
</tr>
<tr>
<td>Male</td>
<td>89.5 (0.82)</td>
<td>62.4 (5.47)</td>
</tr>
<tr>
<td>Female</td>
<td>73.7 (1.05)</td>
<td>64.3 (1.79)</td>
</tr>
<tr>
<td>Age</td>
<td>Unadjusted Mean</td>
<td>Adjusted Mean</td>
</tr>
<tr>
<td>60-64</td>
<td>85.4 (1.82)</td>
<td>85.5 (1.83)</td>
</tr>
<tr>
<td>65-69</td>
<td>81.9 (1.56)</td>
<td>81.7 (1.49)</td>
</tr>
<tr>
<td>70-74</td>
<td>80.1 (1.08)</td>
<td>80.3 (1.08)</td>
</tr>
<tr>
<td>75-80</td>
<td>76.2 (1.26)</td>
<td>76.1 (1.27)</td>
</tr>
</tbody>
</table>
Table D.3 Gender and age unadjusted and adjusted means for average handgrip strength

<table>
<thead>
<tr>
<th>Variable</th>
<th>Unadjusted Mean</th>
<th>Adjusted Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>38.6 (0.54)</td>
<td>28.0 (2.33)</td>
</tr>
<tr>
<td>Female</td>
<td>23.7 (0.23)</td>
<td>17.7 (3.16)</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
</tr>
<tr>
<td>60-64</td>
<td>33.5 (0.67)</td>
<td>33.7 (0.69)</td>
</tr>
<tr>
<td>65-69</td>
<td>32.0 (0.74)</td>
<td>31.9 (0.74)</td>
</tr>
<tr>
<td>70-74</td>
<td>30.0 (0.38)</td>
<td>30.1 (0.38)</td>
</tr>
<tr>
<td>75-80</td>
<td>26.4 (0.38)</td>
<td>26.4 (0.39)</td>
</tr>
<tr>
<td>Race</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mexican American</td>
<td>28.2 (0.65)</td>
<td>26.6 (1.5)</td>
</tr>
<tr>
<td>Other Hispanic</td>
<td>28.5 (0.91)</td>
<td>23.5 (1.34)</td>
</tr>
<tr>
<td>NH White</td>
<td>31.0 (0.50)</td>
<td>26.5 (0.42)</td>
</tr>
<tr>
<td>NH Black</td>
<td>31.9 (0.71)</td>
<td>27.3 (2.3)</td>
</tr>
<tr>
<td>Other race</td>
<td>28.7 (0.87)</td>
<td>23.5 (2.35)</td>
</tr>
</tbody>
</table>

Table D.4 Gender and age unadjusted and adjusted means for sedentary hours

<table>
<thead>
<tr>
<th>Variable</th>
<th>Unadjusted Mean</th>
<th>Adjusted Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>7.3 (0.13)</td>
<td>8.8 (0.73)</td>
</tr>
<tr>
<td>Female</td>
<td>7.1 (0.13)</td>
<td>7.5 (0.58)</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
</tr>
<tr>
<td>60-64</td>
<td>7.25 (0.26)</td>
<td>7.25 (0.26)</td>
</tr>
<tr>
<td>65-69</td>
<td>6.61 (0.21)</td>
<td>6.61 (0.21)</td>
</tr>
<tr>
<td>70-74</td>
<td>7.0 (0.19)</td>
<td>7.0 (0.19)</td>
</tr>
<tr>
<td>75-80</td>
<td>7.7 (0.22)</td>
<td>7.7 (0.22)</td>
</tr>
</tbody>
</table>
# APPENDIX E: Hypothesis Testing Interactions

Table E.1 Hypothesis testing results for not significant (p>0.05) association on individual scents variables

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Scent: Smoke (smoke_ST)</th>
<th>Scent Gas (gas_ST)</th>
<th>Scent: Grape (grape_ST)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Socio-Demographic</td>
<td>marital_status, RIDRETH1, SMQ020</td>
<td>RIDRETH1, Educ, Income, marital_status, SMQ020</td>
<td>Gender, RIDRETH1, Educ, Income, marital_status, SMQ020</td>
</tr>
<tr>
<td>Smell</td>
<td>CSQ200, CSQ204, CS240, CSQ250</td>
<td>CSQ200, CSQ204, CS240, CSQ250</td>
<td>CSQ200, CSQ204, CS240, CSQ250, smell_alt</td>
</tr>
<tr>
<td>Health/Strength</td>
<td>rated_health, appetite, IADL_imp, person_active, dominanthand_g</td>
<td>rated_health, appetite, IADL_imp, hours_sedentary</td>
<td>rated_health, appetite, IADL_imp, person_active</td>
</tr>
<tr>
<td>Weight</td>
<td>WC1y_cat, WC1y10_cat, current weight, BMICat</td>
<td>WC1y_cat, WC1y10_cat, current weight, BMICat</td>
<td>WC1y_cat, WC1y10_cat, current weight, BMICat</td>
</tr>
</tbody>
</table>

Table E.2 Hypothesis Testing results for not significant (p>0.05) associations on smell scores variables

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Scent Test Total Score (ST_totals)</th>
<th>Smell Alteration Total Score (smellalt_totals)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Socio-Demographic</td>
<td>marital_status, SMQ020</td>
<td>Gender, RIDRETH1, Educ, Income, marital_status, SMQ020</td>
</tr>
<tr>
<td>Smell</td>
<td>CSQ200, CSQ204, CS240, CSQ250</td>
<td>CSQ200, CSQ204, CS240, CSQ250</td>
</tr>
<tr>
<td>Health/Strength</td>
<td>appetite, IADL_imp, person_active</td>
<td>rated_health, appetite, musclet_cat2</td>
</tr>
<tr>
<td>Weight</td>
<td>WC1y_cat, WC1y10_cat</td>
<td>WC1y_cat, WC1y10_cat</td>
</tr>
</tbody>
</table>
Table E.3 Hypothesis testing results for not significant (p>0.05) associations on health assessment variables

<table>
<thead>
<tr>
<th>Sedentary Hours (hours_sedentary)</th>
<th>Socio-Demographic</th>
<th>Educ, Income, SMQ020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smell</td>
<td>smell_alt, smellalt_totals, CSQ200, CSQ204, CS240, CSQ250</td>
<td></td>
</tr>
<tr>
<td>Health/Strength</td>
<td>appetite</td>
<td></td>
</tr>
<tr>
<td>Weight</td>
<td>WC1y_cat, WC1y10_cat, BMIcat</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Average Hand Grip Strength (dominanthand_gt)</th>
<th>Socio-Demographic</th>
<th>Income</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smell</td>
<td>smell_imp, smell_alt, CSQ200, CSQ204, CS240, CSQ250</td>
<td></td>
</tr>
<tr>
<td>Health/Strength</td>
<td>n/a</td>
<td></td>
</tr>
<tr>
<td>Weight</td>
<td>WC1y_cat, WC1y10_cat</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Muscle Strength Categories (musclest_cat2)</th>
<th>Socio-Demographic</th>
<th>RIDRETH1, SMQ020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smell</td>
<td>n/a</td>
<td></td>
</tr>
<tr>
<td>Health/Strength</td>
<td>appetite</td>
<td></td>
</tr>
<tr>
<td>Weight</td>
<td>WC1y_cat</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Categories of BMI (BMIcat)</th>
<th>Smell</th>
<th>smell_imp, straw_ST, smoke_ST, grape_ST</th>
</tr>
</thead>
<tbody>
<tr>
<td>Health/Strength</td>
<td>hours_sedentary, person_active</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Rated Health (rated_health) &amp; Appetite*</th>
<th>Socio-Demographic</th>
<th>Agecat</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Physical Activity (person_active)*</th>
<th>Socio-Demographic</th>
<th>Agecat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Health/Strength</td>
<td>appetite</td>
<td></td>
</tr>
</tbody>
</table>

Variables were tested only against: rated_health, appetite, age and person_active
BIOGRAPHY OF THE AUTHOR

Emily Duran-Frontera was born in Moca, Puerto Rico on December 12, 1995. She was raised in Las Marias, Puerto Rico and graduated from Escuela Superior Eva y Patria Custodio in 2013. She attended the University of Maine and graduated in 2017 with a Bachelor’s degree in Food Science and Human Nutrition. She entered the combined Dietetic Internship and Master’s graduate program at The University of Maine in the fall of 2017. After receiving her degree, Emily will join her fiancee in their new life adventure. She is a candidate for the Master of Science in Food Science and Human Nutrition from the University of Maine in August 2019.